# A HANDBOOK

OF

# Petroleum, Asphalt and Natural Gas

Methods of Analysis, Specifications, Properties, Refining Processes, Statistics, Tables and Bibliography

BY


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# PREFACE

The purpose of this publication is to set forth in concise form for the petroleum producer, seller, refiner and technologist, scientific information and statistics on the production, properties, handling, refining and methods of valuation of petroleum and related products.

All matter formerly published in Bulletin No. 14 has been revised and included in this publication. In addition there has been added, fifty-five new illustrations, complete temperature-Baumé correction tables, extensive tank gauging tables, refinery engineering formulae, complete specifications for petroleum products, much additional data on oil cracking, geology, lubricants and asphalt, a complete set of methods of analysis of petroleum, asphalt and natural gas and a fairly complete bibliography.

The sources of original information have been from the research, commercial and engineering departments of the Kansas City Testing Laboratory and from the bibliography published at the end of the book.

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## CONTENTS.

(General outline only—see index for detailed subject matter.)

# Value of Petroleum as a Mineral Product

On page 32 is a statement showing the value and amount of production of the most important marketed mineral products of the United States in 1918. An examination of this table, as well as other tables on this page, shows that petroleum in the United States in 1918 exceeded in value any of the metals except iron which it equalled in value and was greater than the combined value of gold, silver, copper, lead and zinc. Coal was the only mined product exceeding it in value.

The chief change in the demand for petroleum products has been its relative limitation as fuel for steam or stationary power plant purposes and its increase in use for lubrication and for automobile engines. However, nearly one-half of the consumption of petroleum is still due to its use as fuel. More than 100 million barrels of petroleum could, should and probably will eventually be replaced by coal. The U. S. Navy normally may be expected to consume at least six million barrels of fuel oil per year and there are some industries which require the flexibility of fuel oil and its low sulphur content with absence of ash. The price of coal must, in the long run, very largely govern the price of petroleum products as the demand for gasoline increases and gasoline must remain at the present or higher price. The governing factor in this situation has been the gasoline automobile. It is quite apparent that the point of saturation for automobiles has not been reached as is indicated by the following table showing the demand for gasoline.

| Year | Automobiles | Gasoline | Per Cent from Crude Oil |
|---|---|---|---|
| 1905 | 85,000 | 7,900,000 | 5.91 |
| 1910 | 400,000 | 14,750,000 | 7.04 |
| 1914 | 1,253,000 | 34,900,000 | 13.14 |
| 1916 | 2,225,000 | 49,020,000 | 19.85 |
| 1917 | 3,250,000 | 64,290,000 | 21.15 |
| 1918 | 4,500,000 | 86,561,150 | 26.07 |

The increase in automobiles must diminish or the increase in the percentage of gasoline obtainable from crude oil must continue.

During 1918 practically the entire increase in gasoline production was due to an additional production of cracked or artificial gasoline almost entirely from the Standard Oil Company. It is probable that the limit has been reached for the quality of gasoline as there has been no change in the past year. It does not seem probable that a satisfactory automobile engine will be worked out soon which will be capable of handling distillate mixed with gasoline as it seems that the increased efficiency by reason of cracking the heavy oil in the cracking plant or refinery easily offsets the lower price of distillate that might be used by cracking it in the automobile cylinder.

Wax and lubricants are the most valuable products of the refining of petroleum, both of which have shown very great increases in amount produced during the past year. For this purpose, however, the highest grades of petroleum are necessary and very elaborate and expensive refinery equipments are required for their production. It

seems that Mexican and other high sulphur oils must, to a large extent, in the very near future be the source of fuel oils. When, however, natural petroleum has passed as a fuel a very abundant potential source of synthetic petroleum exists in the oil shales and cannel coal. The destructive distillation of oil shales yields fuel oil, lubricating oil, wax and illuminating oil. The very substantial yield of wax and lubricants particularly may stimulate an earlier development of the oil shale industry than might otherwise be expected.

The following outlines some of the uses of petroleum products:

Gasoline and Naphtha—Gas lighting, laboratory solvents, cleansing, gasoline stoves, automobiles, extraction of seed oils, metal polishes, gasoline engines, paint vehicles, asphalt paint and road binder solvent.

Kerosene and Illuminating Oils—Lamps, distillate engines, signal lights, gas washing and absorbents, portable stoves.

Gas Oil—Pintsch gas, Blaugas, town gas, straw oil, heating, cracking, anti-corrosives.

Heavy Distillates—Lubricants, spindle oil, auto oil, machine oil, engine oil, cylinder oil, greases, vaseline, wax, medicinal oil, waterproofing for fabrics, candles, soap filler, paints, polishes.

Liquid Residua—Steam production, heating, concrete waterproofing, road and macadam oils, dust prevention, cracking.

Semi-Solid Residua—Asphalt pavement, waterproofing, brick filler, roofing, rubber filler or substitute.

Crude Oils—Diesel engines, dust prevention, waterproofing.

# Geological Occurrence of Petroleum and Natural Gas

The following summarizes the geological conditions under which petroleum and natural gas occur:

1. They occur in sedimentary rocks of all geologic ages from Silurian upward. The most productive areas are the Paleozoic in North America and the Miocene in Russia.

2. There is no relation of the occurrence of petroleum to volcanic or igneous action. There seems to be some relation particularly in the carboniferous and the Mississippian to the deposits of coal.

3. The most productive areas for oil in great quantity are where the strata are comparatively undisturbed. Oil frequently occurs where the strata are highly contorted and disturbed but in less abundance, and gas is usually absent.

4. In comparatively undisturbed as well as in disturbed areas a folded or dome structure often favors the accumulation of oil and gas in the domes or anticlines.

5. Important requisites for a productive oil or gas field are an impervious cap rock or cover and a porous reservoir.

6. Salt water almost universally accompanies oil and gas in the same sand.

In the United States, oil is found most abundantly in the Tertiary rocks in California and the Gulf Coast, in upper cretaceous in Wyoming, in carboniferous locally known as the Cherokee Shales in the Mid-Continent field, in the sub-carboniferous or Mississippian and the Upper Devonian in the Appalachian field and in Illinois, and in the Ordovician in Ohio and Indiana. The oils from the Tertiary are heavy and of low grade, those from the cretaceous, carboniferous and sub-carboniferous are light, high grade oils. The Mississippian in the Mid-Continent field is not supposed to carry any oil and very little is known of it or deeper strata in this territory. It is assumed that the deeper strata have vanished west of the Ozark uplift.

The accumulation of petroleum occurs in a pervious reservoir which usually consists of a loose sand though it may be a coarse gravel or a disrupted shale or limestone. It is merely necessary that the rock should contain a considerable amount of voids. The ordinary sand will have from 15 per cent to 35 per cent of voids and the amount of oil contained and the ease with which it is discharged into a well vary greatly. As a general rule, one gallon of oil may be obtained from one cubic foot of oil sand. It is probable that never over 75 per cent of the oil surrounding a well is discharged into it even with the lighter oils, and the per cent abstracted is much lower with the heavier and more viscous oils. Porous sand and gravel and heavy gas pressure are conducive to rapid expulsion of oil. Fine sand and low pressure give steadily producing wells of great longevity. The ultimate production of a well would be determined by the depth and extent of the sand, the physical character of the sand, the physical character of the oil and the pressure. Water is a very important element in the actual production of a well. It frequently

causes very extensive subterranean oil movements destroying one productive structure and making new productive structures.

In nearly every oil sand there occur together, gas, oil and salt water. The gas invariably occupies the uppermost portion of the sand, the salt water, the bottom with the oil intermediate. The sand usually lies at the same angle or dip as the stratum in which it is contained, so that this fact forms the basis, to a great extent, of the geologist's work. It is to be noted that the surface topography has no relation to the probable location of oil or the dip or "strike" of the formation beneath the surface. Asphalt exposures are not good indications of oil in the immediate vicinity but indicate that oil may be found of good quality where this same geological structure is capped by an impervious cover. Anticlines bear no definite relation to surface topography, though the anticline is more likely to be found corresponding in a general way to the bottom of an old river or stream bed than corresponding to the divide between two streams.

Oil of good quality is usually found at sufficient depth that the lighter fractions have not evaporated, though some good wells are found at depths as shallow as 250 feet. The best wells of the Mid-Continent field vary from 1,000 to 3,500 feet in depth. The deepest well in the United States is the Lake Well in Harrison County, West Virginia, and is 7579 feet deep. Wells at Ranger, Texas, are about 3,400 feet deep. A well in Banner County, Nebraska, is 5,600 feet deep. Named in order of depth, the four deepest wells in the world are the Lake; the Goff, West Virginia, 7,386 feet, and a well at Czuchow, Germany, 7,348. In comparison with these great depths, other depths reached by wells or mines sunk in the crust of the earth are rather insignificant. The deepest mine in the world is Shaft No. 3 of the Tamarack mine, in Houghton County, Michigan, which has reached a depth of 5,200 feet.

The preponderance of evidence points to the theory that the greater part of petroleum has been produced from organic matter of any kind undergoing decomposition, followed by its segregation by the action of water and accumulation in pervious rocks of the oil produced. Other theories are that oil originated from animal matter and also that it came from the reaction of metallic carbides at high pressure with water.

A demonstration as to the origin of petroleum hydrocarbons is very readily made by the use of the cracking test described on page 319. By heating corn oil, cottonseed oil or other vegetable or animal oil a product is made which is identical in boiling point range with that of ordinary crude oil though it contains a rather large amount of volatile fatty acids. An almost exact duplication of crude petroleum oil can be produced with this apparatus by placing lime in the receptacle with the vegetable oil. In this case the light distillate is almost entirely composed of paraffin hydrocarbons.

## TEMPERATURE IN WELLS (WEST VIRGINIA)

| | |
|---|---|
| 100 feet | 55.6° |
| 1,000 feet | 65.3° |
| 2,000 feet | 74.9° |
| 3,000 feet | 87.6° |
| 5,000 feet | 114.2° |
| 6,000 feet | 132.1° |
| 7,000 feet | 153.2° |
| 7,310 feet | 158.3° |

The rate of temperature increase varies continuously from 1 degree Fahr. in 97.5 feet at the surface to 1 degree Fahr. in 46.5 feet over the interval 6,000 to 7,000 feet. In the Texas and Oklahoma oil fields temperatures at a given depth differ widely from those found in Pennsylvania and West Virginia. The temperature of the oil in two wells near Mannington, W. Va., is 83.2 degrees Fahr. at a depth of about 2,900 feet. In the Ranger field, Texas, the temperature of the oil at 3,400 feet is estimated, from measurements at higher levels, to be about 135 degrees. The average rate of temperature increase at the surface for thirteen wells in Texas and Oklahoma is about 1 degree Fahr. in 51 feet, as compared with 1 degree in 91.5 feet for twelve wells in Pennsylvania and West Virginia.

## SUMMARIZED TABLE OF OIL OCCURRENCES IN THE UNITED STATES

| Field | Structure | Geologic Age | Kind of Rock | Kind of Petroleum |
|---|---|---|---|---|
| Appalachian or Eastern | Geo-Syncline with subordinate anticlines | Ordovician to Carboniferous | Sandstone | Paraffin base |
| Ohio-Indiana | Anticlines | Ordovician | Mostly limestone | Paraffin base |
| Illinois | Low anticlines | Carboniferous | Sandstone | Paraffin and semi-paraffin base |
| Mid-Continent | Anticlines | Carboniferous | Sandstone | Paraffin semi-paraffin base |
| Wyoming | Folds | Carboniferous to Tertiary | Mostly sandstone | Paraffin and asphalt base |
| Gulf Coast | Domes | Tertiary and Cretaceous | Dolomite and sandstone | Asphalt base |
| California | Folds and Faults | Tertiary | Sandstone, shales and conglomerates | Asphalt base |
| Mexico | .............. | Tertiary | .............. | Asphalt base |

## TYPICAL COMPOSITION OF "MISSISSIPPI LIME" AT TOP

(From Wilson County, Kansas)

| | |
|---|---|
| Carbon dioxide | 32.0% |
| Silica + Insoluble | 20.5% |
| Iron and Alumina ($R_2O_3$) | 3.3% |
| Lime ($CaO$) | 23.4% |
| Magnesia ($MgO$) | 11.8% |

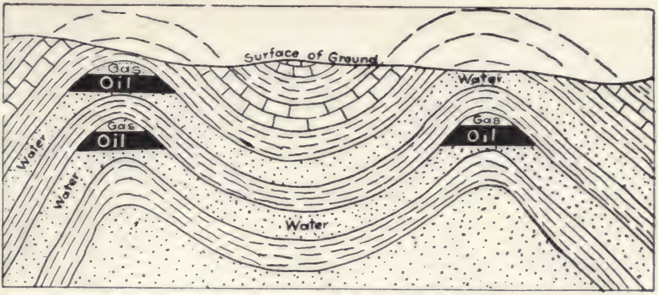



Diagram representing the accumulation of oil and gas in anticlines.

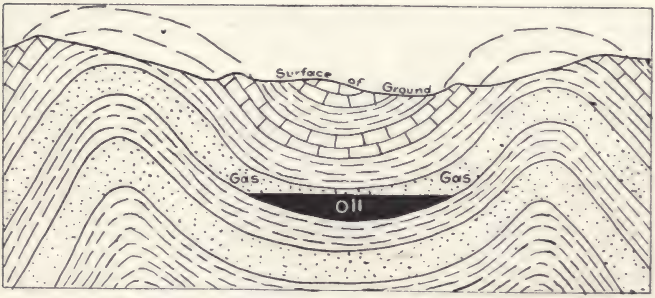
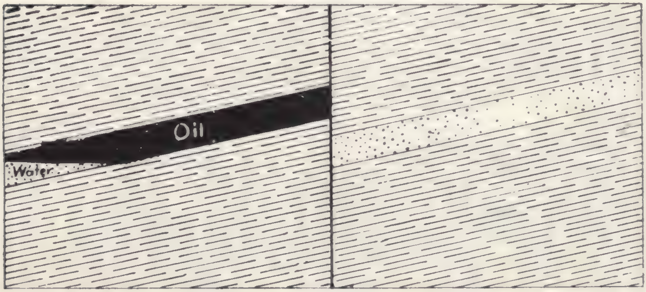



Diagram showing the accumulation of oil in a syncline in the absence of water




Ideal section showing an oil sand faulted in such a manner that an accumulation of oil will result

# Stratigraphic Section of Rocks in the Oil-Bearing Region of Kansas

(Kansas Geological Survey)

## PERMIAN SERIES

| | Thickness |
|---|---|
| Wellington Formation— | |
| Sandstone, limestone, shale, salt and gypsum | 400-600 |
| Marion Formation— | |
| Abilene Conglomerate | 25-50 |
| Pearl Shale | 55-75 |
| Herington Limestone | 12-15 |
| Enterprise Shale | 30-50 |
| Luta Limestone | 20-40 |
| Chase Formation— | |
| Winfield Limestone | 20-25 |
| Doyle Shale | 50-70 |
| Fort Riley Limestone | 40-45 |
| Florence Flint | 15-25 |
| Matfield Shale | 60-70 |
| Wreford Limestone | 35-50 |
| Council Grove Formation— | |
| Garrison Limestone and Shale | 135-150 |
| Cottonwood Limestone | 5-7 |

## PENNSYLVANIAN SERIES

| | |
|---|---|
| Wabaunsee Formation— | |
| Eskridge Shale | 30-40 |
| Neva Limestone | 3-5 |
| Elmdale Shale | 120-140 |
| Americus Limestone | 6-10 |
| Admire Shale, possibly contains shallow oil sand at Eldorado | 275-325 |
| Emporia Limestone | 5-10 |
| Willard Shale | 45-55 |
| Burlingame Limestone | 7-12 |
| Shawnee Formation— | |
| Scranton Shale | 160-200 |
| Howard Limestone | 3-7 |
| Severy Shale | 40-60 |
| Topeka Limestone | 20-25 |
| Calhoun Shale | 0-50 |
| Deer Creek Limestone | 20-30 |
| Tecumseh Shale | 40-70 |
| Lecompton Limestone | 15-30 |
| Kanawha Shale | 50-100 |
| Douglas Formation— | |
| Oread Limestone | 50-70 |
| Lawrence Shale, including Chautauqua Sandstone member, probably 1,500 feet sand at Augusta and Eldorado | 150-300 |
| Iatan Limestone | 3-15 |
| Weston Shale | 60-100 |

## PENNSYLVANIAN SERIES—Continued

| | Thickness |
|---|---|
| Lansing Formation— | |
| Stanton Limestone | 20-40 |
| Vilas Shale | 5-125 |
| Plattsburg Limestone | 5-80 |
| Lane Shale | 50-150 |
| Kansas City Formation— | |
| Iola Limestone | 2-40 |
| Chanute Shale | 25-100 |
| Drum Limestone | 0-30 |
| Cherryvale Shale—possibly horizon of oil sand at 2,400 feet at Augusta and Eldorado | 25-125 |
| Winterset Limestone | 30-40 |
| Galesburg Shale | 10-60 |
| Bethany Falls Limestone | 4-25 |
| Ladore Shale | 3-50 |
| Hertha Limestone | 10-20 |
| Marmaton Formation— | |
| Pleasanton Shale | 100-150 |
| Coffeyville Limestone | 8-10 |
| Walnut Shale | 60-80 |
| Altamont Limestone | 3-10 |
| Bandera Shale | 60-120 |
| Pawnee Limestone (Big Lime) | 40-50 |
| Labette Shale (Horizon Peru Oil Sand) | 0-60 |
| Fort Scott (Oswego) Limestone | 20-40 |
| Cherokee Formation— | |
| Cherokee Shale—includes the main oil sands outside Augusta and Eldorado and Peru—contains Bartlesville and Burgess sands | 400-500 |
| Mississippian Limestone— | |
| Limestone, calcareous shale and chert shown in Neosho well—Boone Formation | 320 |
| Probably Older than Mississippian— | |
| 1—Dolomitic limestone, sandstone and chert shown in Neosho well | 77 |
| 2—Conglomerate and shale in Neosho well | 23 |
| 3—Sandstone, conglomerate with pebbles up to three-quarters inch diameter; shown in Neosho well | 1823 |

# Stratigraphic Section in Main Oil and Gas District of Northern Oklahoma

(Oklahoma Geological Survey and Other Sources)

## PERMIAN SERIES

| | Thickness Feet |
|---|---|
| 1—Red and gray sandstone, clay-iron conglomerates, red and vari-colored shale, thin beds of concretionary limestone near base, beds of gypsum and salt in the upper portion. Quartermaster, Greer, Woodward, Blaine and upper portions of Enid formations. | 1200-2000 |
| 2—Beds of thin limestone, sandstone and shale. Contains near base the shallow gas sands at Blackwell, Billings and Garber | 500-600 |

## PENNSYLVANIAN SERIES

| | |
|---|---|
| **Ralston Group—** | |
| Consists of red and gray sandstone, red shale and beds of thin limestone. Contains the Hoy oil sand at Garber. | |
| 1—Upper division down to Pawhuska limestone, inclusive | 650 |
| 2—Lower division down to Elgin sandstone | 140 |
| **Sapulpa Group—** | |
| 1—Elgin Sandstone. Probable horizon of shallow oil sand in the Newkirk field and at Ponca City | 20-150 |
| 2—Oread Limestone. | 0-20 |
| 3—Buxton Sandstone and Shale. Horizon of main oil sand at Ponca City and gas at Myers | 700-1000 |
| 4—Avant Limestone. | 0-10 |
| 5—Ramona formation. Sandstone, shale and thin limestone beds. Includes Lost City limestone and the Musselman oil sands of the Cushing-Cleveland areas. | 300-400 |
| 6—Dewey Limestone. | 15-25 |
| 7—Skiatook formation. Sandstone, shale and thin limestone beds. Includes Hogshooter limestone and Layton oil sand | 350-400 |
| 8—Lenapah Limestone. | 10-20 |
| **Tulsa Group—** | |
| 1—Nowata Shale—includes the Wayside oil sand and its correlations (local coal bed, Dawson coal) | 75-150 |
| 2—Oolagah Limestone or "Big Lime" of the drillers | 20-50 |
| 3—Labette Shale. Sandstone, shale and beds of thin limestone. Includes the Cleveland and Peru oil sands. | 250-300 |
| 4—Oswego Limestone (Fort Scott) | 25-100 |

| | Thickness Feet |
|---|---|
| Muskogee Group— | |
| Beds of shale, sandstone and thin limestone correlating with the Cherokee shale (Boggy and Winslow formations at Muskogee). Includes the main oil sands of Oklahoma, the Red Fork, Bartlesville, (Glenn), Tucker, Taneha, Booch, Morris and Muskogee sands, the latter lying at the unconformable base of the Pennsylvania series | 450-1500 |
| (Unconformity) | |
| **MISSISSIPPIAN SERIES** | |
| 1—Morrow Limestone | 100-200 |
| (Unconformity) | |
| 2—Pitkin Limestone | 40-60 |
| 3—Fayetteville formation. Sandstone, shale and limestone contains the Mounds oil sand and a deep sand near Sapulpa | 20-200 |
| (Unconformity) | |
| 4—Boone formation. Massive white limestone and massive beds of chert | 200-400 |
| **DEVONIAN SYSTEM** | |
| 1—Chattanooga formation. Black fissile shale | 30-50 |
| 2—Sylamore sandstone, clear quartz sandstone | 0-25 |
| (Unconformity) | |
| **ORDIVICIAN SYSTEM** | |
| 1—Turner formation. Thin sandstone and limestone in shale | 60-100 |
| 2—Burgen (St. Peter) sandstone, massive quartz sandstone | 5-100 |
| **CAMBRIAN SYSTEM** | |
| Massive limestone beds shown in Harrington well at Joplin, Mo. | 1165 |

# World's Production of Petroleum

| Country | Total Production 1857 to 1917 | | Production 1916 | | Production 1917 | | Production 1918 | |
|---|---|---|---|---|---|---|---|---|
| | Barrels | Per Cent | Barrels | Per Cent | Barrels | Per Cent | Barrels | Per Cent |
| United States | 4,252,644,003 | 60.89 | 300,767,158 | 65.29 | 335,315,601 | 66.98 | 345,500,000 | 66.94 |
| Russia | 1,832,583,017 | 26.24 | 72,801,110 | 15.81 | 69,000,000 | 13.78 | 65,000,000 | 12.59 |
| Mexico | 222,082,472 | 3.18 | 39,817,402 | 8.64 | 55,292,770 | 11.04 | 64,605,422 | 12.52 |
| Dutch East Indies | 175,103,267 | 2.51 | 13,174,399 | 2.86 | 12,928,955 | 2.58 | 13,000,000 | 2.52 |
| Roumania | 142,992,465 | 2.05 | 10,298,208 | 2.24 | 2,681,870 | .54 | 2,900,000 | 0.56 |
| India | 98,583,522 | 2.41 | 8,228,571 | 1.79 | 8,500,000 | 1.70 | 8,500,000 | 1.65 |
| Galicia | 148,459,653 | 2.13 | 6,461,706 | 1.40 | 5,965,447 | 1.19 | 6,000,000 | 1.16 |
| Japan and Formosa | 36,065,454 | .52 | 2,997,178 | 0.65 | 2,898,654 | .58 | 2,750,000 | 0.53 |
| Peru | 21,878,285 | .31 | 2,550,645 | 0.55 | 2,533,417 | .51 | 2,500,000 | 0.48 |
| Trinidad | 5,418,885 | .08 | 1,000,000 | 0.22 | 1,599,455 | .32 | 1,600,000 | 0.31 |
| Germany | 15,952,861 | 2.30 | 995,764 | 0.22 | 995,764 | .20 | 1,000,000 | 0.19 |
| Argentina | 3,047,858 | 0.04 | 870,000 | 0.19 | 1,144,737 | .23 | 1,000,000 | 0.19 |
| Egypt | 2,768,686 | .04 | 411,000 | 0.09 | 1,008,750 | .20 | 1,000,000 | 0.19 |
| Canada | 24,112,529 | 3.50 | 198,123 | 0.04 | 205,332 | .04 | 300,000 | 0.06 |
| Italy | 947,289 | .01 | 43,143 | 0.01 | 50,334 | .01 | 50,000 | 0.01 |
| Other countries | 927,000 | .01 | 25,000 | 0.01 | 530,000 | .10 | 500,000 | 0.10 |
| | 6,983,567,246 | 100.00 | 460,639,407 | 100.00 | 500,651,086 | 100.00 | 516,205,422 | 100.00 |

## PETROLEUM PRODUCTION BY STATES.

| State | 1915 | 1916 | 1917 | 1918 |
|---|---|---|---|---|
| Oklahoma | 97,915,243 | 111,000,000 | 97,600,000 | 84,950,300 |
| California | 86,591,535 | 92,000,000 | 97,000,000 | 101,493,000 |
| Texas | 17,467,598 | 26,000,000 | 30,000,000 | 42,000,000 |
| Illinois | 19,041,695 | 16,500,000 | 11,000,000 | 11,000,000 |
| Louisiana | 18,191,539 | 17,000,000 | 15,000,000 | 15,900,000 |
| West Virginia | 9,264,798 | 8,500,000 | 8,000,000 | 8,000,000 |
| Pennsylvania | 7,838,705 | 8,000,000 | 8,000,000 | 8,000,000 |
| Ohio | 7,825,325 | 7,400,000 | 7,000,000 | 8,000,000 |
| Kansas | 2,823,487 | 11,500,000 | 38,000,000 | 43,253,470 |
| Wyoming-Montana | 4,245,525 | 6,300,000 | 10,000,000 | 13,815,000 |
| Kentucky | 437,274 | 1,200,000 | 4,000,000 | 7,000,000 |
| Indiana | 875,758 | 1,000,000 | 1,000,000 | 1,000,000 |
| New York | 887,778 | 900,000 | 900,000 | 900,000 |
| Colorado | 208,475 | 190,000 | 200,000 | 200,000 |
| Other States | 14,262 | 10,000 | 10,000 | 10,000 |
| | 281,104,104 | 307,500,000 | 327,610,000 | 345,521,770 |

## PRODUCTION OF PETROLEUM BY DISTRICTS

| Field | 1917 | 1918 |
|---|---|---|
| Appalachian | 24,932,205 | 25,300,000 |
| Lima-Indiana | 3,670,293 | 3,100,000 |
| Illinois | 15,776,360 | 13,300,000 |
| Oklahoma-Kansas | 155,043,596 | 139,600,000 |
| Central and Northern Texas | 10,900,646 | 15,600,000 |
| North Louisiana | 8,561,963 | 13,000,000 |
| Gulf Coast | 26,087,587 | 21,700,000 |
| Rocky Mountain | 9,199,310 | 12,600,000 |
| California | 93,877,549 | 101,300,000 |
| Alaska and Michigan | 10,300 | .......... |
| Totals | 335,315,601 | 345,500,000 |

## SOURCES OF CRUDE OIL IN THE UNITED STATES IN 1918

| | Barrels |
|---|---|
| Produced in the United States | 339,400,000 |
| Drawn from stocks | 27,000,000 |
| Imported (Mexico) | 37,735,000 |
| Total | 404,135,000 |

## DISPOSITION OF CRUDE OIL IN U. S. IN 1918

| | Barrels |
|---|---|
| Total amount refined | 326,024,630 |
| Exported | 4,900,000 |
| Unrefined sold as fuel and road oil | 73,210,370 |
| | 404,135,000 |

## PETROLEUM MARKETED IN THE UNITED

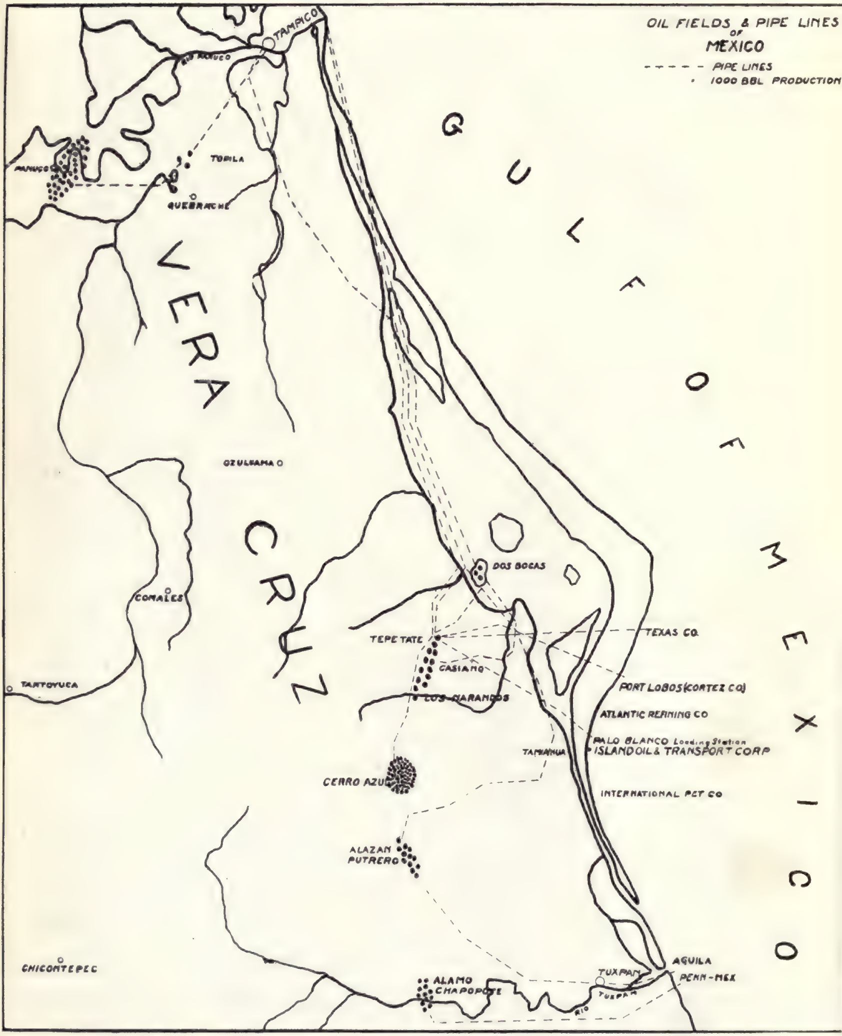
| Year | Pennsylvania and New York | Ohio | West Virginia | California | Kentucky and Tennessee | Colorado | Indiana | Illinois |
|---|---|---|---|---|---|---|---|---|
| | Barrels | Barrels | Barrels | Barrels | Barrels | Barrels | Barrels | Barrels |
| 1859 | 2,000 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1860 | 500,000 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1861 | 2,113,609 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1862 | 3,056,690 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1863 | 2,611.309 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1864 | 2,116,109 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1865 | 2,497.700 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1866 | 3,597,700 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1867 | 3,347,300 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1868 | 3,646,117 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1869 | 4,215,000 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1870 | 5,260,745 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1871 | 5.205,234 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1872 | 6,293.194 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1873 | 9.893,786 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1874 | 10,926,945 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1875 | 8,787,514 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1876 | 8,968.906 | 31,763 | 120,000 | 12,000 | ........ | ........ | ........ | ........ |
| 1877 | 13,135,475 | 29,888 | 172,000 | 13,000 | ........ | ........ | ........ | ........ |
| 1878 | 15,163.462 | 38,179 | 180,000 | 15,227 | ........ | ........ | ........ | ........ |
| 1879 | 19,685,176 | 29,112 | 180,000 | 19,858 | ........ | ........ | ........ | ........ |
| 1880 | 26,027,631 | 38,940 | 179,000 | 40,552 | ........ | ........ | ........ | ........ |
| 1881 | 27.376,509 | 33,867 | 151,000 | 99,862 | ........ | ........ | ........ | ........ |
| 1882 | 30,053,500 | 39,761 | 128,000 | 128,636 | ........ | ........ | ........ | ........ |
| 1883 | 23,128,389 | 47,632 | 126,000 | 142,857 | 4,755 | ........ | ........ | ........ |
| 1884 | 23,772,209 | 90,081 | 90,000 | 262.000 | 4.148 | ........ | ........ | ........ |
| 1885 | 20,776,401 | 661,580 | 91,000 | 325,000 | 5,164 | ........ | ........ | ........ |
| 1886 | 25,798,000 | 1,782,970 | 102,000 | 377,145 | 4.726 | ........ | ........ | ........ |
| 1887 | 22,356,193 | 5,022,632 | 145,000 | 678,572 | 4.791 | 76,295 | ........ | ........ |
| 1888 | 16,488,668 | 10,010.868 | 119,448 | 690,333 | 5 096 | 297,612 | ........ | ........ |
| 1889 | 21,487,435 | 12,471,466 | 544,113 | 303,220 | 5,400 | 316,476 | 33,375 | 1, |
| 1890 | 28,458,208 | 16,124,656 | 492,578 | 307,360 | 6,000 | 368,842 | 63,496 | |
| 1891 | 33,009,236 | 17,740,301 | 2,406,218 | 323,600 | 9,000 | 665,482 | 136,634 | 6[illegible] |
| 1892 | 28,422,377 | 16,362,921 | 3,810,086 | 385,049 | 6,500 | 824,000 | 698 068 | 521 |
| 1893 | 20.314,513 | 16,249,769 | 8,445.412 | 470,179 | 3,000 | 594,390 | 2,335,293 | 400 |
| 1894 | 19,019,990 | 16,792,154 | 8,577,624 | 705,969 | 1,500 | 515,746 | 3,688,666 | 300 |
| 1895 | 19,144,390 | 19,545,233 | 8,120,125 | 1,208,482 | 1,500 | 438,232 | 4,386,132 | 200 |
| 1896 | 20,584,421 | 23,941,169 | 10,019,770 | 1,252,777 | 1,680 | 361,450 | 4,680,732 | 250 |
| 1897 | 19,262,066 | 21,560,515 | 13,090,045 | 1,903,411 | 322 | 384,934 | 4,122,356 | 500 |
| 1898 | 15,948,464 | 18,738,708 | 13,615,101 | 2,257,207 | 5,568 | 444,383 | 3,730,907 | 360 |
| 1899 | 14,374,512 | 21,142,108 | 13,910,630 | 2,642,095 | 18,280 | 390,278 | 3,848,182 | 360 |
| 1900 | 14,559,127 | 22,362,730 | 16,195,675 | 4,324,484 | 62,259 | 317,385 | 4,874.392 | 200 |
| 1901 | 13,831,996 | 21,648,083 | 14,177,126 | 8,786,330 | 137,259 | 460,520 | 5,757,086 | 250 |
| 1902 | 13,183,610 | 21,014,231 | 13,513,345 | 13,984,268 | 185,331 | 396,901 | 7,480,896 | 200 |
| 1903 | 12,518,134 | 20.480,286 | 12,899,395 | 24,382,472 | 554,286 | 483,925 | 9,186,411 | ........ |
| 1904 | 12,239,026 | 18,876,631 | 12,644,686 | 29,649,434 | 998.284 | 501,763 | 11,339,124 | ........ |
| 1905 | 11,554,777 | 16,346,600 | 11,578.110 | 33,427,473 | 1,217,337 | 376,238 | 10,964,247 | 181,084 |
| 1906 | 11,500,410 | 14,787,763 | 10,120,935 | 33,098,598 | 1,213,548 | 327,582 | 7,673,477 | 4,397,050 |
| 1907 | 11,211,606 | 12,207,448 | 9,095,296 | 39,748,375 | 820,844 | 331,851 | 5.128,037 | 24,281,973 |
| 1908 | 10.584,453 | 10,858,797 | 9,523,176 | 44,854,737 | f727,767 | 379,653 | 3,283,629 | 33,686,238 |
| 1909 | 10,434,300 | 10,632,793 | 10,745.092 | 55,471,601 | f639,016 | 310,861 | 2,296,086 | 30,898,339 |
| 1910 | 9,848,500 | 9,916,370 | 11,753,071 | 73,010,560 | f468,774 | 239.794 | 2,159,725 | 33,143,362 |
| 1911 | 9,200,673 | 8,817,112 | 9,795,464 | 81,134,391 | f472,458 | 226,926 | 1,695,289 | 31,317,038 |
| 1912 | 8,712,076 | a8,969,007 | 12,128,962 | g87,272,593 | f484,368 | 206,052 | 970,009 | 28,601,308 |
| 1913 | 8,865,493 | 8,781,468 | 11,567,299 | 97,788,525 | f524,568 | 188,799 | 956,095 | 23.893,899 |
| 1914 | 9,109,309 | 8,536,352 | 9,680,033 | 99,775,327 | 502,441 | 222,773 | 1,335,456 | 21,919,749 |
| 1915 | 8,726,483 | 7,825,326 | 9,264,798 | 86,591,535 | f437,274 | 208,475 | 875,758 | 19,041,695 |
| | 762,906,696 | 440,587,330 | 269,497,613 | 827,865,091 | 9,533.214 | 10,857,618 | 103,699,558 | 251,368,311 |

a Includes the production of Michigan.
b Includes the production of Oklahoma.
c Included with Kansas.
d Estimated.
e Includes production of Utah.

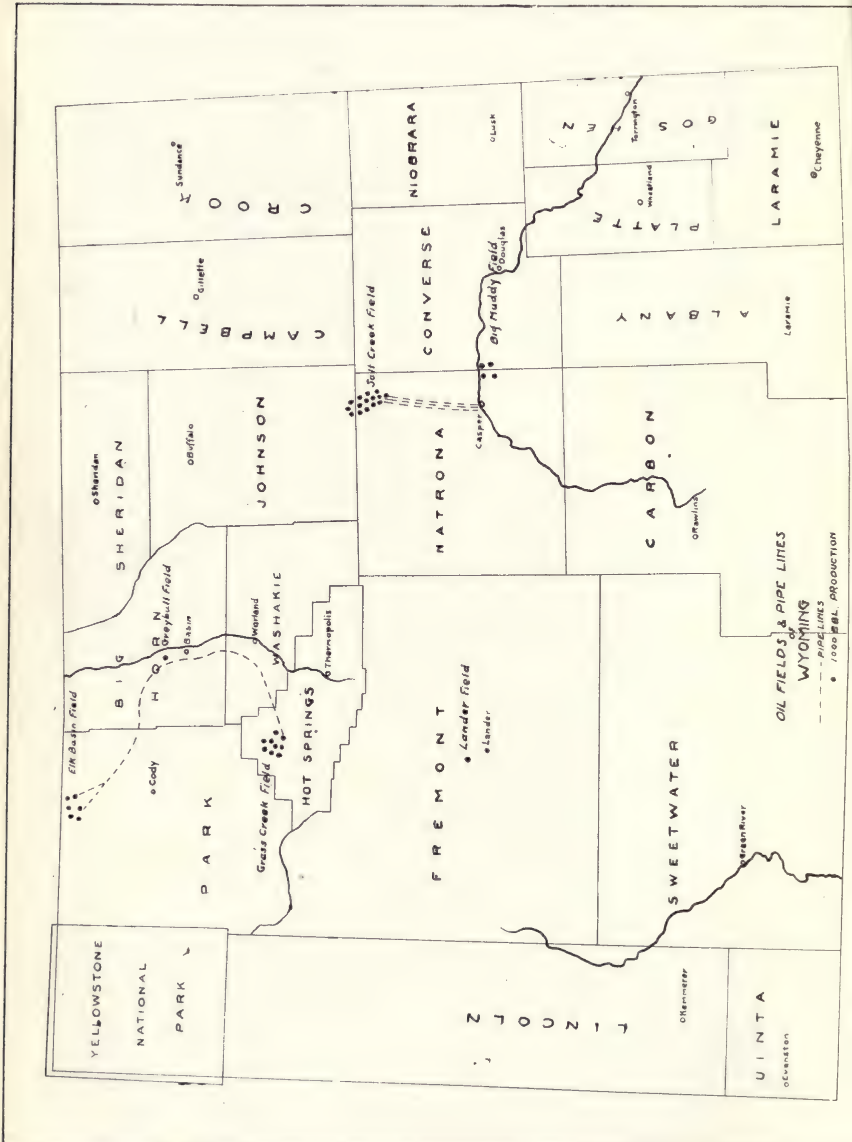
**STATES, 1859-1915 (in 42-Gal. Bbls.)**

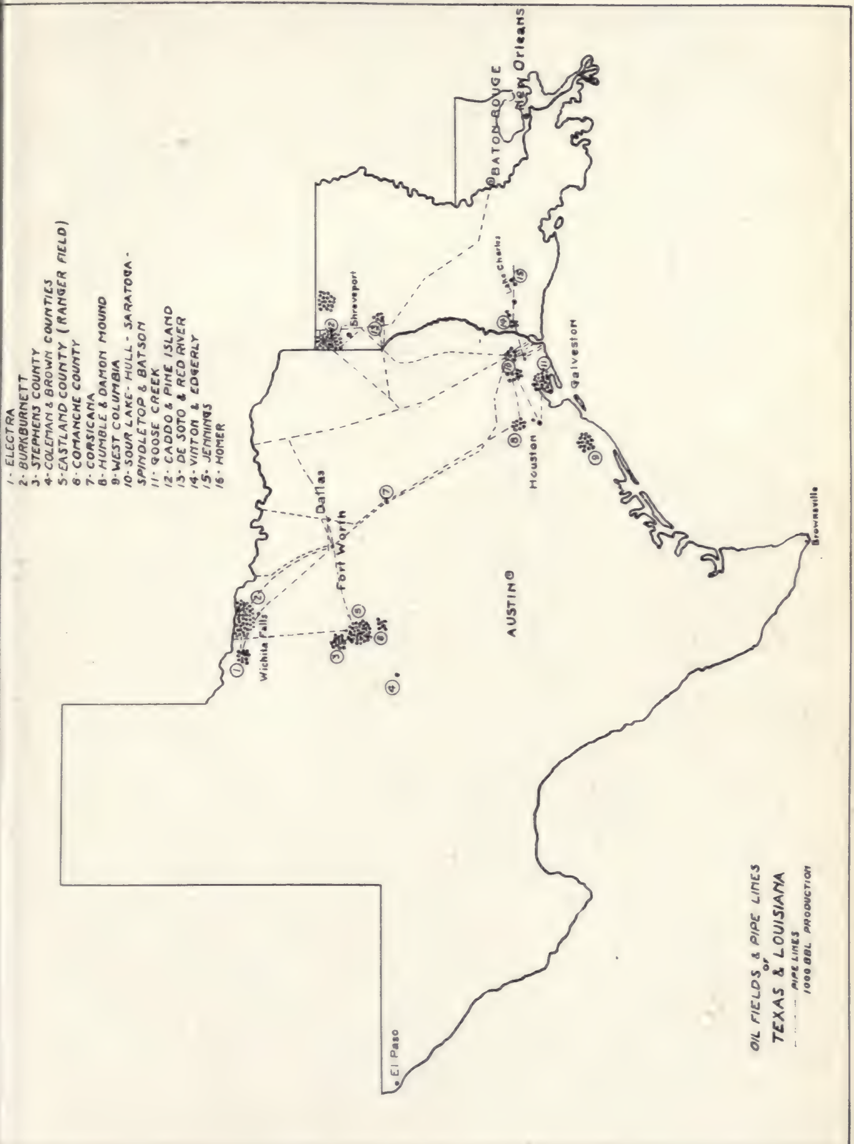
| Kansas | Texas | Missouri | Oklahoma | Wyoming | Louisiana | United States | Total Value | Year |
|---|---|---|---|---|---|---|---|---|
| Barrels | Barrels | Barrels | Barrels | Barrels | Barrels | Barrels | | |
| | | | | | | 2,000 | $32,000 | 1859 |
| | | | | | | 500,000 | 4,800,000 | 1860 |
| | | | | | | 2,113,609 | 1,035,668 | 1861 |
| | | | | | | 3,056,690 | 3,209,525 | 1862 |
| | | | | | | 2,611.309 | 8,225,663 | 1863 |
| | | | | | | 2,116,109 | 20,896,576 | 1864 |
| | | | | | | 2,497,700 | 16,459,853 | 1865 |
| | | | | | | 3,597,700 | 13,455,398 | 1866 |
| | | | | | | 3,347,300 | 8,066,993 | 1867 |
| | | | | | | 3,646,117 | 13,217,174 | 1868 |
| | | | | | | 4,215,000 | 23,730,450 | 1869 |
| | | | | | | 5,260,745 | 20,503,754 | 1870 |
| | | | | | | 5.205 234 | 22,591,180 | 1871 |
| | | | | | | 6,293,194 | 21,440,503 | 1872 |
| | | | | | | 9,893,786 | 18,100,464 | 1873 |
| | | | | | | 10,926,945 | 12,647,527 | 1874 |
| | | | | | | 8,787,514 | 7,368,133 | 1875 |
| | | | | | | 9,132,669 | 22,982,822 | 1876 |
| | | | | | | 13,350,363 | 31,788,566 | 1877 |
| | | | | | | 15.396,868 | 18,044,520 | 1878 |
| | | | | | | 19,914.146 | 17,210,708 | 1879 |
| | | | | | | 26,286,123 | 24,600,638 | 1880 |
| | | | | | | 27.661,238 | 25,448,339 | 1881 |
| | | | | | | 30,349,897 | 23,631,165 | 1882 |
| | | | | | | 23 449,633 | 25.790,252 | 1883 |
| | | | | | | 24,218,438 | 20,595,936 | 1884 |
| | | | | | | 21,858,785 | 19,198,243 | 1885 |
| | | | | | | 28.064,841 | 19.996,313 | 1886 |
| | | | | | | 28.283.483 | 18,877,094 | 1887 |
| | | | | | | 27,612,025 | 17,947,620 | 1888 |
| 500 | 48 | 20 | | | | 35.163,513 | 26,963,340 | 1889 |
| 1,200 | 54 | 278 | | | | 45,823.572 | 35,365,105 | 1890 |
| 1,400 | 54 | 25 | 30 | | | 54,292,655 | 30 526,553 | 1891 |
| 5.000 | 45 | 10 | 80 | | | 50,514,657 | 25,906,463 | 1892 |
| 18,000 | 50 | 50 | 10 | | | 48,431,066 | 28.950.326 | 1893 |
| 40,000 | 60 | 8 | 130 | 2.369 | | 49,344,516 | 35,522,095 | 1894 |
| 44.430 | 50 | 10 | 37 | 3,455 | | 52,892,276 | 57,632,296 | 1895 |
| 113,571 | 1,450 | 43 | 170 | 2 878 | | 60,960,361 | 58,518,709 | 1896 |
| 81,098 | 65,975 | 19 | 625 | 3,650 | | 60,475,516 | 40,874,072 | 1897 |
| 71 980 | 546,070 | 10 | | 5,475 | | 55,364.233 | 44,193.359 | 1898 |
| 69,700 | 669.013 | 132 | | 5 560 | | 57,070,850 | 64 603.904 | 1899 |
| 74,714 | 836,039 | a1,602 | 6,472 | 5 450 | | 63,620,529 | 75,989,313 | 1900 |
| 179,151 | 4,393,658 | a2,335 | 10,000 | 5,400 | | 69,389.194 | 66,417.335 | 1901 |
| 331,749 | 18.083,658 | a757 | 37,100 | 6,253 | 548 617 | 88,766,916 | 71,178,910 | 1902 |
| 932,214 | 17,955,572 | a3,000 | 138,911 | 8,960 | 917.771 | 100,461,337 | 94,694,050 | 1903 |
| 4,250,779 | 22,241,413 | a2,572 | 1,366,748 | 11,542 | 2,958,958 | 117,080,960 | 101,175,455 | 1904 |
| b12 013,495 | 28,136,189 | a3,100 | (c) | 8,454 | 8,910,416 | 134,717,580 | 84,157,399 | 1905 |
| b21.718.648 | 12,567,897 | a3,500 | (c) | d7,000 | 9.077,528 | 126,493 936 | 92,444,735 | 1906 |
| 2,409,521 | 12,332,696 | a4,000 | 43,524,128 | e9,339 | 5 000.221 | 166,095,335 | 120,106,749 | 1907 |
| 1,801 781 | 11,206,464 | a15,246 | 45,798,765 | e17.775 | 5.788 874 | 178,527,355 | 129,079,184 | 1908 |
| 1,263,764 | 9,534,467 | a5,750 | 47,859,218 | e20.056 | 3 059,531 | 183,170,874 | 128,328.487 | 1909 |
| 1,128,669 | 8,899,266 | a3,615 | 52,028,718 | e115,430 | 6,841,395 | 209,557,248 | 127,899,688 | 1910 |
| 1,278,819 | 9,526,474 | a7,995 | 56,069,637 | e186,695 | 10,720,420 | 220.449,391 | 134,044.752 | 1911 |
| 1,592.796 | 11,735,057 | (h) | 51,427,071 | 1,572,306 | 9,263.439 | 222,935 044 | 164,213,247 | 1912 |
| 2,375,029 | 15,009,478 | i10,843 | 63,579,384 | 2,406,522 | 12.498 828 | 248,446,230 | 237,121,388 | 1913 |
| 3,103,585 | 20,068,184 | j7,792 | 73.631,724 | 3,560,375 | 14 309,435 | 265,762,535 | 214,125,215 | 1914 |
| 2,823,487 | 24,942,701 | j14,265 | 97,915,243 | 4,245,525 | 18,191,539 | 281,104,104 | 179,462,890 | 1915 |
| 57,725 079 | 228,742,082 | 86,977 | 533,394,201 | 12,210.469 | 108.086,972 | 3616561.244 | 2971388,126 | |

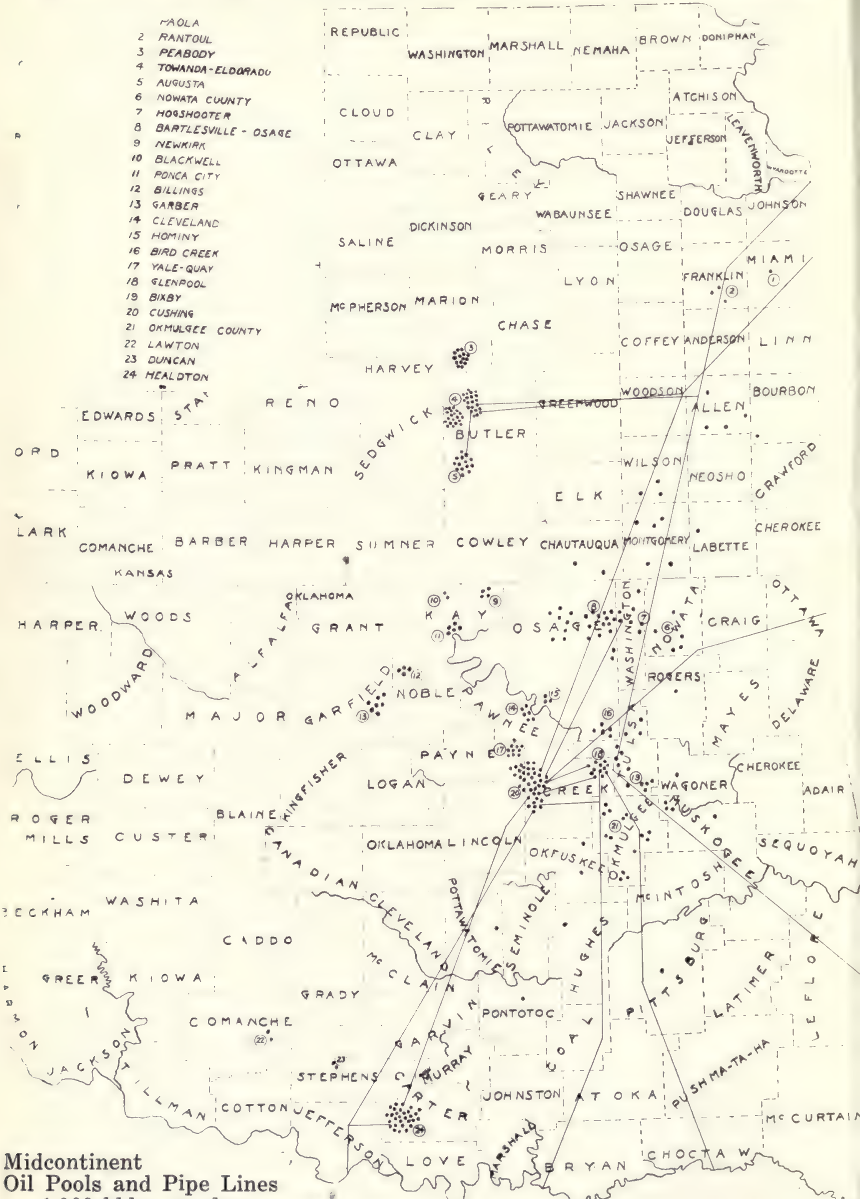
f No production in Tennessee recorded.
g Includes small production of Alaska.
h No production in Missouri; Michigan included in Ohio.
i Includes production of Alaska, Michigan and New Mexico.
j Includes production of Alaska and Michigan.


OIL FIELDS & PIPE LINES OF MEXICO
PIPE LINES
1000 BBL PRODUCTION
GULF OF MEXICO
VERA CRUZ
TAMPICO
TOPILA
QUEBRACHE
OZULUAMA
COMALES
TANTOYUCA
DOS BOCAS
TEPETATE
CASIANO
LOS NARANJOS
TEXAS CO.
PORT LOBOS (CORTEZ CO.)
ATLANTIC REFINING CO
PALO BLANCO Loading Station
ISLAND OIL & TRANSPORT CORP
TAMIAHUA
INTERNATIONAL PET CO
CERRO AZUL
ALAZAN
POTRERO
CHICONTEPEC
ALAMO
CHAPOPOTE
TUXPAN
RIO TUXPAN
AGUILA
PENN-MEX

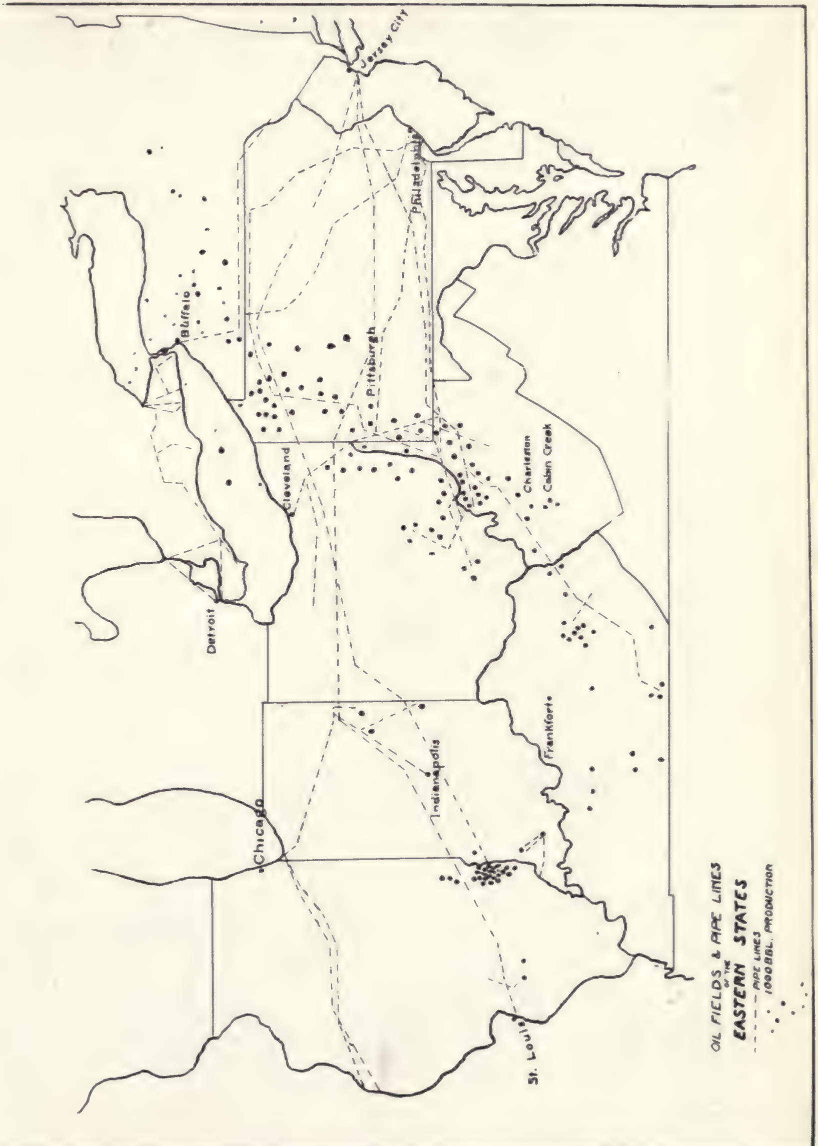

OIL FIELDS & PIPE LINES OF CALIFORNIA

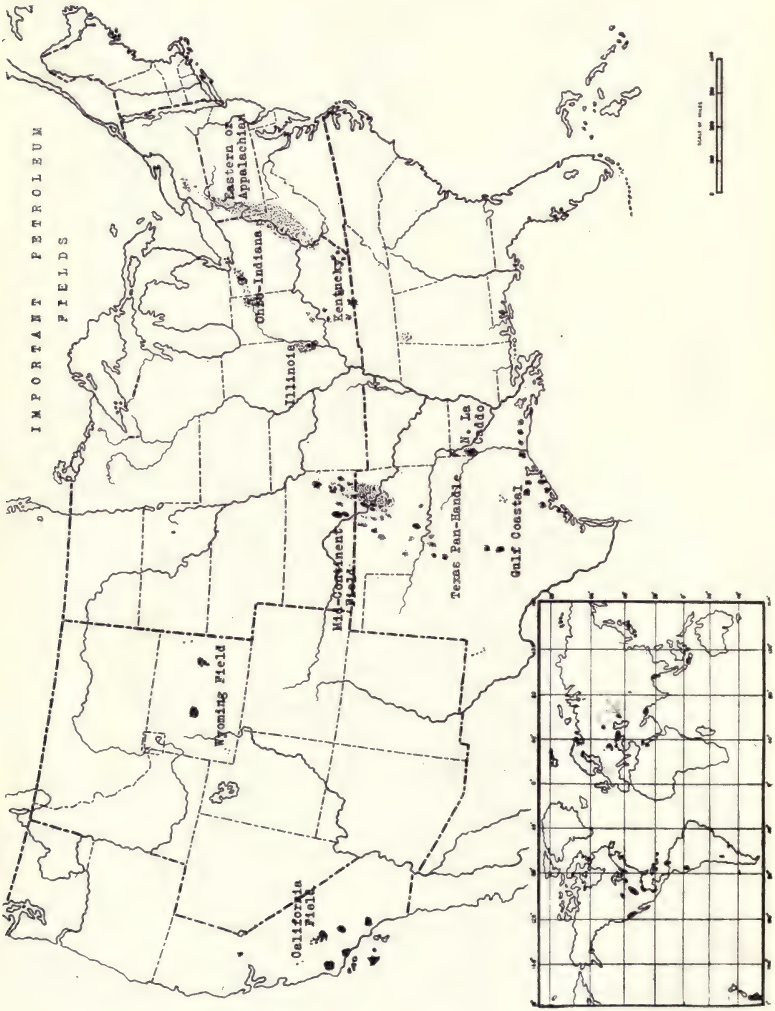

OIL FIELDS & PIPE LINES
of
WYOMING
- - - - PIPE LINES
• 1000 BBL. PRODUCTION
CROOK
Sundance
CAMPBELL
Gillette
NIOBRARA
Lusk
GOSHEN
Torrington
PLATTE
Wheatland
LARAMIE
Cheyenne
CONVERSE
Douglas
Big Muddy Field
Salt Creek Field
SHERIDAN
Sheridan
JOHNSON
Buffalo
NATRONA
Casper
ALBANY
Laramie
CARBON
Rawlins
BIG HORN
Greybull Field
Basin
WASHAKIE
Worland
HOT SPRINGS
Thermopolis
Elk Basin Field
Cody
PARK
Grass Creek Field
FREMONT
Lander Field
Lander
SWEETWATER
Green River
YELLOWSTONE NATIONAL PARK
LINCOLN
Kemmerer
UINTA
Evanston


1 · ELECTRA
2 · BURKBURNETT
3 · STEPHENS COUNTY
4 · COLEMAN & BROWN COUNTIES
5 · EASTLAND COUNTY (RANGER FIELD)
6 · COMANCHE COUNTY
7 · CORSICANA
8 · HUMBLE & DAMON MOUND
9 · WEST COLUMBIA
10 · SOUR LAKE - HULL - SARATOGA - SPINDLETOP & BATSON
11 · GOOSE CREEK
12 · CADDO & PINE ISLAND
13 · DE SOTO & RED RIVER
14 · VINTON & EDGERLY
15 · JENNINGS
16 · HOMER
Shreveport
BATON ROUGE
New Orleans
Lake Charles
Galveston
Houston
Dallas
Fort Worth
AUSTIN
Wichita Falls
Brownsville
El Paso
OIL FIELDS & PIPE LINES OF TEXAS & LOUISIANA
PIPE LINES
1000 BBL PRODUCTION




Midcontinent
Oil Pools and Pipe Lines
. = 1,000 bbls. per day.


OIL FIELDS & PIPE LINES OF THE EASTERN STATES
PIPE LINES
1000 BBL. PRODUCTION
Jersey City
Philadelphia
Buffalo
Pittsburgh
Cleveland
Detroit
Charleston
Cabin Creek
Frankfort
Indianapolis
Chicago
St. Louis


IMPORTANT PETROLEUM FIELDS
Eastern or Appalachia
Ohio-Indiana
Kentucky
Illinois
N. La Caddo
Texas Pan-Handle
Gulf Coastal
Mid-Continent Field
Wyoming Field
California Field

# Production of Natural Gas-Gasoline in 1917

## By Compression and by Vacuum Pumps

| State | No. | Gasoline Produced, Quantity, Gallons | Gas Used, Estimated Volume M Cu. Ft. | Avg. Yield of Gasoline per M Cu. Ft. Gallons |
|---|---|---|---|---|
| Oklahoma | 207 | 108,728,213 | 36,399,280 | 2.987 |
| California | 40 | 23,478,521 | 27,477,443 | 0.854 |
| West Virginia | 159 | 12,276,784 | 4,845,648 | 2.534 |
| Pennsylvania | 234 | 9,011,199 | 3,572,356 | 2.522 |
| Louisiana | 18 | 4,459,920 | 1,468,346 | 3.037 |
| Illinois | 54 | 4,268,158 | 2,020,044 | 2.113 |
| Texas | 9 | 3,997,337 | 2,685,316 | 1.489 |
| Ohio | 54 | 2,331,498 | 836,639 | 2.788 |
| New York | 5 | .......... | ......... | ..... |
| Kansas | 1 | .......... | ......... | ..... |
| Kentucky | 3 | 369,925 | 150,784 | 2.453 |
| Colorado | 1 | .......... | ......... | ..... |
| Totals | 785 | 168,921,555 | 79,455,856 | 2.126 |

## By Absorption

| State | No. | Gasoline Produced, Quantity, Gallons | Gas Used, Estimated Volume M Cu. Ft. | Avg. Yield of Gasoline per M Cu. Ft. Gallons |
|---|---|---|---|---|
| West Virginia | 29 | 20,391,863 | 163,925,703 | 0.125 |
| Oklahoma | 27 | 6,395,211 | 48,320,661 | 0.132 |
| California | 9 | 5,339,083 | 17,873,804 | 0.299 |
| Pennsylvania | 17 | 4,815,051 | 45,914,700 | 0.105 |
| Kentucky | 2 | 3,725,893 | 24,871,590 | 0.150 |
| Ohio | 7 | 3,108,062 | 29,225,502 | 0.106 |
| Texas | 3 | 2,978,068 | 10,010,233 | 0.298 |
| Kansas | 5 | 1,071,633 | 9,274,289 | 0.116 |
| Illinois | 1 | 665,851 | 665,851 | 1.000 |
| Louisiana | 2 | 519,834 | 675,165 | 0.770 |
| New York | .. | 7,000 | 2,776 | ..... |
| Colorado | .. | .......... | ......... | ..... |
| Totals | 102 | 49,017,549 | 349,760,274 | 0.140 |

## TOTAL GASOLINE FROM NATURAL GAS MARKETED IN THE UNITED STATES IN 1917

| State | No. Plants | Daily Capacity Gallons | Quantity Gallons | Price per Gallon Cents | Average Yield of Gasoline M Cu. Ft. Gas Gals. |
|---|---|---|---|---|---|
| Oklahoma | 234 | 492,436 | 115,123,424 | 18.71 | 1.359 |
| West Virginia | 188 | 135,663 | 32,668,647 | 19.93 | 0.195 |
| California | 49 | 99,761 | 28,817,604 | 15.40 | 0.635 |
| Pennsylvania | 251 | 59,164 | 13,826,250 | 20.01 | 0.279 |
| Texas | 11 | 32,550 | 6,920,405 | 16.61 | 0.546 |
| Ohio | 61 | 25,137 | 5,489,560 | 19.38 | 0.181 |
| Louisiana | 20 | 20,118 | 4,979,754 | 16.36 | 2.323 |
| Illinois | 55 | 17,302 | 4,934,009 | 17.55 | 1.837 |
| Kentucky | 5 | 13,400 | 3,818,209 | 19.99 | 0.153 |
| Kansas | 6 | 4,642 | 1,174,980 | 20.53 | 0.126 |
| New York | ... | ...... | .......... | ..... | ..... |
| Colorado | 6 | 2,122 | 181,262 | 18.27 | 2.659 |
| Totals | 886 | 902,385 | 217,884,104 | 18.45 | 0.508 |

## CASINGHEAD GASOLINE INDUSTRY

The growth of the casinghead gasoline industry since 1911 is shown by the following table:

| | Plants | Production |
|---|---|---|
| 1911 | 8 | 338,058 |
| 1912 | 13 | 1,575,644 |
| 1913 | 40 | 6,462,968 |
| 1914 | 58 | 17,277,555 |
| 1915 | 63 | 31,665,991 |
| 1916 | 116 | 48,359,602 |

# Daily Production of Crude Oil—Various Fields

| | | | Barrels |
|---|---|---|---|
| California Daily Production, January, 1919 | | | 275,596 |
| | Wells Producing | Production per Day | |
| Kern River | 1,996 | 20,460 | |
| McKittrick | 333 | 7,806 | |
| Midway-Sunset | 2,208 | 87,871 | |
| Lost Hills-Belridge | 535 | 13,374 | |
| Coalinga | 1,140 | 43,805 | |
| Santa Maria-Lompoc | 343 | 17,520 | |
| Ventura County-Newhall | 456 | 4,503 | |
| Los Angeles-Salt Lake | 664 | 3,979 | |
| Whittier-Fullerton | 784 | 76,056 | |
| Summerland | 142 | 147 | |
| Watsonville | 5 | 75 | |
| Totals | 8,606 | 275,596 | |

Average value per barrel, $1.23

| | | | |
|---|---|---|---|
| Kentucky Daily Production, January, 1919 | | | 21,020 |
| Big Sinking | | 12,000 | |
| Pilot | | 2,060 | |
| Ross Creek | | 1,900 | |
| Ravenna | | 1,530 | |
| Fitchburg | | 1,420 | |
| Zachariah | | 1,000 | |
| Fallsburg | | 250 | |
| Steubenville | | 150 | |
| Ragland | | 150 | |
| Parmleyville | | 150 | |
| Cooper | | 150 | |
| Busseyville, Beaver Creek, Campton, Denney, Cannel City, Stillwater, Wagersville | | 300 | |
| Louisiana Daily Production, January, 1919 | | | 53,200 |
| North Louisiana | | 46,200 | |
| Caddo and Pine Island | 40,000 | | |
| De Soto and Red River | 6,200 | | |
| South Louisiana | | 7,000 | |
| Vinton | 4,000 | | |
| Edgerly | 1,800 | | |
| Jennings | 1,200 | | |
| Wyoming Daily Production, 1918 | | | 35,500 |
| Salt Creek Field | | 15,000 | |
| Grass Creek | | 9,000 | |
| Elk Basin | | 6,000 | |
| Big Muddy | | 4,000 | |
| Lander | | 1,000 | |
| Greybull and Basin | | 500 | |

| | | | |
|---|---|---|---|
| Texas Daily Production, 1919 | | | 310,265 |
| High Gravity Crude Oil (North Texas) (Oct. 1) | | 242,890 | |
| Burkburnett | 86,000 | | |
| Eastland (Ranger) | 66,100 | | |
| Electra | 11,000 | | |
| Stephens County | 44,800 | | |
| Comanche County and Miscellaneous | 31,350 | | |
| Petrolia | 750 | | |
| Holliday | 175 | | |
| Thrall | 90 | | |
| Strawn | 500 | | |
| Moran | 150 | | |
| Coleman and Brown Counties | 1,000 | | |
| Northeast Texas | 400 | | |
| Somerset and Bexar Counties | 300 | | |
| Piedras Pintas | 100 | | |
| Iowa Park | 100 | | |
| Cameron County | 75 | | |
| Low Gravity Crude Oil (South Texas) (Oct. 1) | | 67,375 | |
| Goose Creek | 22,000 | | |
| West Columbia | 15,000 | | |
| Humble | 10,000 | | |
| Sour Lake | 8,000 | | |
| Hull | 5,000 | | |
| Saratoga | 2,100 | | |
| Spindletop | 1,500 | | |
| Batson | 1,450 | | |
| Damon Mound | 1,200 | | |
| Corsicana | 900 | | |
| Markham | 150 | | |
| Dayton | 25 | | |
| Miscellaneous | 50 | | |
| Mexico Daily Production (Average for 1918) | | | 177,000 |
| South Fields | | 135,800 | |
| Panuco | | 35,000 | |
| Ebano | | 3,960 | |
| Topila | | 2,240 | |
| Oklahoma-Kansas (Mid-Continent) Average Daily Production, January, 1919 | | | 295,693 |
| Washington County— | | | |
| Bartlesville | 4,283 | | |
| Hogshooter | 1,627 | | |
| Copan-Wann | 481 | 6,391 | |
| Nowata-Rogers Counties— | | | |
| Nowata | 3,487 | | |
| Delaware | 1,300 | | |
| Chelsea | 1,200 | | |
| Inola | 297 | 6,284 | |
| Osage County | 31,888 | 31,888 | |

| | | |
|---|---|---|
| Tulsa County— | | |
| Bird Creek | 6,807 | |
| Lost City and Red Fork | 752 | |
| Broken Arrow and Jenks | 2,151 | |
| Bixby and Leonard | 3,872 | 13,582 |
| Okmulgee County— | | |
| Mounds, Beggs and Youngstown | 2,569 | |
| Hamilton Switch | 3,541 | |
| Bald Hill | 5,393 | |
| Morris | 2,481 | |
| Tiger Flats | 2,805 | |
| Schulter | 198 | |
| Henryetta | 191 | 17,178 |
| Muskogee and Wagoner Counties— | | |
| Coweta | 1,280 | |
| Haskell and Stone Bluff | 1,528 | |
| Boynton-Cole | 1,986 | |
| Muskogee | 500 | 5,294 |
| Pawnee County— | | |
| Cleveland | 6,948 | 6,948 |
| Creek County— | | |
| Cushing-Shamrock | 41,807 | |
| Glenn, Sapulpa and Kiefer | 16,801 | |
| Kellyville-Bristow | 1,183 | |
| Mannford and Olive | 832 | 60,623 |
| Payne County— | | |
| Yale, Quay, etc | 11,800 | 11,800 |
| Kay County— | | |
| Blackwell | 4,980 | |
| Newkirk and Mervine | 4,328 | |
| Ponca City | 581 | 9,889 |
| Garfield and Noble Counties— | | |
| Billings | 4,029 | |
| Garber | 6,400 | 10,429 |
| Carter County— | | |
| Healdton and Fox | 38,803 | 38,803 |
| Miscellaneous | | 2,105 |
| Total Oklahoma | | 221,214 |
| Kansas— | | |
| El Dorado | 46,281 | |
| Augusta | 13,400 | |
| Outside | 14,798 | 74,479 |

## PRODUCTION AND DECLINE OF INDIVIDUAL OIL WELLS

### Mid-Continent Field, 1916

| | |
|---|---|
| Total number of wells drilled during year | 11,240 |
| Total number of dry holes (including gas) | 1,970 |
| Total number with gas | 475 |
| Total producing at end of year | 9,270 |
| Per cent producing at end of year | 92.5% |
| Average production of this year's producing wells drilled during the year | 26 Bbls. |
| Average production of all this year's producing wells, including dry holes | 21.5 Bbls. |
| Total number of wells drilled up to end of this year | 81,150 |
| Total number of wells drilled and producing at end of this year | 43,420 |
| Per cent of wells drilled now productive | 53.2% |
| Average production of all producing wells in field per day, including this year | 8 Bbls. |
| Average production of all producing wells drilled excluding this year | 3 Bbls. |

## OIL WELLS DRILLED IN UNITED STATES IN 1917-1918

| | Completed | | Dry | |
|---|---|---|---|---|
| District | 1917 | 1918 | 1917 | 1918 |
| Pennsylvania | 5,435 | 4,400 | 985 | 738 |
| Lima-Indiana | 800 | 793 | 140 | 140 |
| Central Ohio | 582 | 605 | 139 | 159 |
| Kentucky-Tennessee | 1,651 | 2,191 | 411 | 360 |
| Illinois | 647 | 396 | 151 | 108 |
| Kansas | 3,469 | 4,671 | 547 | 925 |
| Oklahoma-Arkansas | 6,717 | 8,381 | 1,334 | 2,116 |
| Texas Panhandle | 1,020 | 1,140 | 262 | 625 |
| North Louisiana | 472 | 534 | 110 | 105 |
| Gulf Coast | 1,562 | 1,597 | 639 | 625 |
| Total | 22,355 | 24,708 | 4,718 | 5,901 |

Wells drilled during 1917 producing oil at end of year.............70.11%
Wells drilled during 1918 producing oil at end of year.............76.12%

## OIL WELLS IN MEXICO, 1919

The total number of wells is 1,056, as follows:

| | |
|---|---|
| Wells located | 131 |
| Wells being driven | 114 |
| Wells in production | 298 |
| Wells not profitable | 27 |
| Wells exhausted | 64 |
| Wells not producing | 422 |
| Total | 1,056 |

The largest number of productive wells belong to the following companies:

| | |
|---|---|
| Aguila Company (Lord Cowdray) | 55 |
| Mexican Petroleum Company of California | 33 |
| The Corona Company | 10 |
| Union Petroleum Company Hispano-Americana | 17 |
| The Texas Company of Mexico | 10 |
| Mexican Gulf Oil Company | 8 |
| Chicholes Oil Company, Ltd | 7 |
| Mexican Combustible Company | 9 |
| Penn. Mex. Fuel Oil Company | 7 |
| Freeport and Mexican Fuel Oil Company | 7 |
| Transcontinental Petroleum Company | 12 |
| Oil Fields of Mexico | 12 |

## RELATIVE ACTIVITY OF OIL FIELDS IN 1918

The rigs and drilling wells, at the close of December, in these fields were as follows:

| Field | Rigs | Drillings | Total |
|---|---|---|---|
| Pennsylvania | 69 | 143 | 212 |
| West Virginia | 94 | 187 | 281 |
| Southeastern Ohio | 33 | 104 | 137 |
| Central Ohio | 31 | 104 | 135 |
| Northwestern Ohio | 11 | 49 | 50 |
| Indiana | 2 | 56 | 58 |
| Illinois | 3 | 51 | 54 |
| Kentucky | 2 | 494 | 496 |
| Tennessee | .... | 16 | 16 |
| Arkansas | 1 | 3 | 4 |
| Kansas | 132 | 481 | 613 |
| Oklahoma | 381 | 1,408 | 1,782 |
| Wyoming | 106 | 165 | 271 |
| Panhandle-Texas | 346 | 1,097 | 1,443 |
| Gulf Coast | 109 | 275 | 384 |
| Louisiana | 146 | 278 | 424 |
| Totals | 1,456 | 4,904 | 6,360 |

These data show that the chief decline in the amount of oil produced occurs in the first year of the life of the oil well. This decline occurs suddenly after the first gushing due to the sudden local relief of pressure. After this, there is a decline due to the gradual exhaustion of the sand. Every reservoir of oil is limited in capacity by the depth of the sand and the degree of impregnation with oil.

As a general rule, 500 barrels of oil is all that may be expected from each acre for each one foot depth of oil-hearing sand though this varies with the porosity and degree of saturation of the sand.

While the chief general cause for decline of oil wells is exhaustion of the sand, there are many causes that account for a decline in individual wells or localities.

# Oil Gushers

The largest oil well in the world is one which came in near Tampico, Mexico, February 10, 1916. It was known as Cero Azul No. 4 and was drilled by the Pan-American Petroleum and Transport Company. The first twenty-four hours of oil flow yielded 260,000 barrels. In two years it is said to have produced approximately 60 million barrels of oil or about one-half of the total production of oil from Mexico. Its initial pressure was 1,035 pounds per square inch and the gravity of the oil is 21° Baume′ and without sediment or water. This well continued to produce at its usual rate during 1918.

It was in September, 1910, that the Mexican Petroleum Company brought in a well in the Juan Casiano field. It showed on a test that it was capable of giving a daily yield of something more than 100,000 barrels of oil. Pipeline connection was made, however, but not until more than 1,500,000 barrels of the inflammable product had been burned in order to prevent it from flowing into Lake Tamaihua, thus endangering boats and other property. It was throttled down to a flow of 20,000 barrels a day and for more than eight years it has been giving this yield. It has yielded, up to this time, more than 65,000,000 barrels of crude petroleum. Accompanying the oil is a gas pressure of 265 pounds per square inch. This natural gas is piped to the top of a hill a mile and a half distant from the well and is there burned in twelve great flares day and night, lighting up the country for a long way around.

On account of the lack of transportation facilities, it has not been allowed to flow at its maximum, being restrained to one million barrels per month at this time.

A number of wells in the Saboontchy-Romany oil fields of Russia have given daily yields of from 75,000 to 120,000 barrels per day for weeks and as much as 7,500,000 barrels in a year.

Another Mexican well at Dos Bocas, south of Tampico, yielded approximately five million barrels within two months.

A well in the Jennings pool in Louisiana in 1904 is reputed to be the largest gusher in the United States and gave 1,275,000 barrels of oil in four months.

Wells in Texas, California and Roumania have yielded 60,000 to 75,000 barrels of oil per day on the initial production.

The largest wells in the Mid-Continent field were in Butler County, Kansas, where, in the Towanda pool, gushers as large as 25,000 barrels per day, initial production, were struck in 1917.

## TABLE SHOWING PRICE PER FOOT FOR DRILLING OIL AND GAS WELLS IN VARIOUS FIELDS

(Oklahoma Geological Survey)

| | Feb. 22, 1916 | June 23, 1917 | July 27, 1917 |
|---|---|---|---|
| To shallow sand in Bartlesville, Nowata and Tulsa districts. | $0.80 to $1.00 | $1.00 to $1.25 | $1.25 |
| To Layton sand in Cushing field. | $1.35 | $1.50 | 2.50 |
| To Bartlesville sand in Cushing field, northwest | 1.50 | 2.00 | 3.50 |
| To Bartlesville sand in Cushing field, southeast | 2.00 | 2.25 | 3.50 to $4.00 |
| To shallow sand in Newkirk, Ponca City and Garber fields. | 1.50 | 1.50 | 1.50 |
| To deeper sands in Newkirk and Ponca City fields (over 2,500 ft.). | 2.50 | 3.50 | 3.50 to 4.00 |
| Healdton field. | 1.40 to 1.50 | 1.75 | 1.75 |
| Electra and Burkburnett to 1,200 ft. depth | 2.00 | | |
| Electra and Burkburnett to 2,100 ft. depth | 8.50 | | |
| Electra and Burkburnett to more than 2,500 ft. depth | 5.00 | | |

Note.—Price for rotary drilling to 2,000 feet is $3.00.

The regular charge for work by the day, February 22, 1917, was $50 for a double shift. This held good throughout the above fields. All wildcat propositions some distance (50 miles or more) from any of the above mentioned fields demanded $3.00 per foot. Contracts were let in 1918-1919, in Pine Island, La., at $11,000-$15,000 per well.

# Refinery Operations on Crude Oil

| | 1916 Quantity | % | 1917 Quantity | % | 1918 Quantity | % |
|---|---|---|---|---|---|---|
| Crude Oil treated, bbls. | 246,922,015 | 100.00 | 315,131,681 | 100.00 | 326,024,630 | 100.00 |
| Gasoline bbls. | 49,020,000 | 19.85 | 67,990,000 | 21.58 | 85,000,000 | 26.07 |
| Kerosene, bbls. | 34,655,000 | 14.03 | 41,120,000 | 13.05 | 43,450,000 | 13.33 |
| Gas and Fuel Oil and Loss, bbls. | 134,290,000 | 54.37 | 148,900,000 | 47.25 | 138,600,000 | 42.51 |
| Lubricating Oil, bbls. | 14,870,000 | 6.02 | 17,945,000 | 5.69 | 20,038,000 | 6.15 |
| Wax, bbls. | 386,180,898 | 0.55 | 481,200,081 | 0.48 | 505,144,357 | 0.49 |
| Coke, tons. | 405,319 | 1.04 | 539,366 | 1.05 | 559,663 | 1.05 |
| Asphalt, tons. | 716,490 | 1.83 | 739,425 | 1.44 | 607,968 | 1.14 |
| Miscellaneous, bbls. | 5,696,000 | 2.31 | 16,720,000 | 5.31 | 15,640,000 | 4.80 |

Miscellaneous includes binder, flux oil, medicinal oil, petroleum, road oil, roofing wax, tar, acid oil, foots oil, motor spirits, pitch, residuum, slops, tar oil, wax oil, wax tailings, straw oil.

## REFINERY OPERATIONS BY DISTRICTS FOR FIRST SIX MONTHS OF 1917

| District | Crude Handled Barrels | Per Cent Gasoline | Per Ce Kerose |
|---|---|---|---|
| Atlantic Coast | 23,454,900 | 22.20 | 22.1 |
| Pennsylvania | 8,659,200 | 24.69 | 21.4 |
| Illinois | 13,830,300 | 35.92 | 14.5 |
| Mid-Continent | 29,260,260 | 26.95 | 14.4 |
| Gulf Coast | 27,543,470 | 12.65 | 11.3 |
| Wyoming | 4,035,800 | 37.43 | 17.0 |
| California | 36,403,400 | 11.14 | 4.2 |
| January-July, 1917 | 143,189,374 | 20.35 | 13.04 |

## INCREASE IN PRODUCTION OF CRACKED GASOLINE
(Estimated from Still Capacity)

| Year | Barrels |
|---|---|
| 1913 | 1,000,000 |
| 1914 | 3,000,000 |
| 1915 | 4,000,000 |
| 1916 | 6,000,000 |
| 1917 | 9,000,000 |
| 1918 | 18,000,000 |

## KINDS OF GASOLINE AND AMOUNT PRODUCED IN 1917

| | |
|---|---|
| Natural or Straight Run | 54,000,000 bbls. |
| Artificial or Cracked | 9,000,000 bbls. |
| From Natural and Casinghead Gas— | |
| By Compression | 4,024,000 bbls. |
| By Absorption | 1,167,000 bbls. |
| Total | 68,191,000 bbls. |

## MARKETED MINERAL PRODUCTS IN THE UNITED STATES IN 1918

| | Quantity | Value | % of World |
|---|---|---|---|
| Refined Petroleum | 366,400,000 bbls. | 1,300,000,000 | 65 |
| Pig Iron ($33.50 per long ton) | 38,820,000 tons | 1,304,000,000 | 30 |
| Copper (24.628c per pound) | 1,869,949,686 lbs. | 460,500,000 | 60 |
| Zinc (8.159c per pound) | 525,122 tons | 85,710,000 | 30 |
| Lead (6.777c per pound) | 550,729 tons | 74,640,000 | 35 |
| Silver (.97875c per ounce) | 67,879,206 oz. | 66,430,000 | 50 |
| Gold ($20.67 per ounce) | 3,314,000 oz. | 68,493,500 | 20 |
| Coal | 651,402,374 tons | .......... | .. |

## PRICES OF CRUDE OIL AT THE WELLS.

### Eastern Fields

| | January 1 1918 | January 1 1919 |
|---|---|---|
| Pennsylvania | $3.75 | $4.00 |
| Cabell | 2.72 | 2.77 |
| Wooster | 2.38 | 2.58 |
| Corning | 2.80 | 2.85 |
| North Lima | 2.08 | 2.38 |
| South Lima | 2.08 | 3.38 |
| Indiana | 1.98 | 2.28 |
| Princeton | 2.12 | 2.60 |
| Somerset | 2.55 | 2.42 |
| Ragland | 1.20 | 2.32 |
| Illinois | 2.12 | 2.42 |
| Plymouth | 2.03 | 2.33 |
| Canada, Petrolia | 2.48 | 2.78 |

### Wyoming Field

| | | |
|---|---|---|
| Elk Basin | 1.85 | 1.85 |
| Grass Creek | 1.75 | 1.85 |
| Big Muddy | 1.40 | 1.50 |
| Salt Creek | 1.40 | 1.50 |

### North Texas Field

| | | |
|---|---|---|
| tra. | 2.00 | 2.25 |
| rietta | 2.00 | 2.25 |
| orsicana, light | 2.00 | 2.25 |
| icana, heavy | 1.05 | 1.30 |
| wn. | 2.00 | 2.25 |
| ger. | 2.00 | 2.25 |

### Mid-Continent Field

| | January 1 1918 | January 1 1919 |
|---|---|---|
| Kansas-Oklahoma | $2.00 | $2.25 |
| Healdton, 32° | 1.20 | 1.45 |
| Cushing | 2.50 | 2.75 |
| Garber | 3.50 | 3.75 |
| Gulf Coast Field | 1.05 | 1.80 |
| Spindletop | 1.00 | 1.80 |
| Goose Creek | 1.00 | 1.80 |
| Sour Lake | 1.00 | 1.80 |
| Humble | 1.00 | 1.80 |
| Batson | 1.00 | 1.80 |
| Saratoga | 1.00 | 1.80 |

### Louisiana Field

| | | |
|---|---|---|
| Caddo, above 38° | 2.00 | 2.25 |
| De Soto, above 38° | 1.90 | 2.15 |
| Caddo, 35° | 1.90 | 2.15 |
| Caddo, 32° | 1.85 | 2.10 |
| Caddo, below 32° | 1.00 | 1.55 |
| Crichton | 1.50 | 1.75 |
| Mexico at Gulf Points | 1.60 | .85 |

### California Field

| | | |
|---|---|---|
| Kern River, etc. | | |
| 14-17.9° | .98 | 1.23 |
| 18-18.9° | .99 | 1.24 |
| Ventura County | | |
| 25-25.9° | 1.07 | 1.32 |
| Fullerton-Whittier | | |
| 16-17.9° | .98 | 1.23 |
| 18-18.9° | .99 | 1.24 |
| 25-25.9° | 1.07 | 1.32 |
| 37-37.9° | 1.32 | 1.57 |

## REFINERY PRODUCTS (1919)

| | Gasoline Gallon | Kerosene Gallon | Fuel Oil Barrel |
|---|---|---|---|
| At Refinery—Oklahoma | 17.2c | 8.0c | $0.75 |
| Kansas City | 22.3c | 10.8c | 1.05 |
| Tulsa | 23.5c | 12.0c | 1.00 |
| Topeka | 22.7c | 11.2c | 1.05 |
| New York City | 24.5c | 14.5c | 4.00 |
| Boston | 25.5c | 10.7c | 4.00 |
| Chicago | 23.0c | 12.0c | 1.60 |
| San Francisco and Los Angeles | 20.5c | 10.5c | 1.60 |
| Seattle | 21.5c | 11.5c | 1.62 |
| New Orleans | 23.0c | 12.0c | 2.00 |

| | | |
|---|---|---|
| Paraffin Wax ... melting point | 103°F | 7½c lb. |
| | 120 | 8½c lb. |
| | 125 | 9c lb. |
| | 128 | 11c lb. |
| | 133 | 13c lb. |
| | 140 | 17c lb. |

Lubricating Oil—

| | |
|---|---|
| Natural | 20c per gallon |
| Black | 20c per gallon |
| Cylinder, Pale | 40c per gallon |
| Cylinder (low cold test) | 60c per gallon |
| Paraffin High Viscosity | 40c per gallon |

Asphalt (at market)—

| | |
|---|---|
| 50 per cent Asphalt Roal Oil, 7c per gallon | $17.50 per ton |
| 70 per cent Asphalt Road Oil, 8c per gallon | 20.00 per ton |
| Texaco Asphalt (Dallas) | 30.00 per ton |
| California (San Francisco) | 13.50 per ton |
| Mexican (Houston) | 20.00 per ton |
| Trinidad (Kansas City) | 32.50 per ton |
| Stanolind (Kansas City) | 20.00 per ton |
| Stanolind (New York) | 20.00 per ton |

Natural Gas ... 6c-60c

## HIGHEST AND LOWEST PRICES OF CRUDE PETROLEUM OF PENNSYLVANIA GRADE, 1859-1918, PER BARREL

| | Highest | | Lowest | |
|---|---|---|---|---|
| Year | Month | Price | Month | Price |
| 1859 | September | $20.00 | December | $20.00 |
| 1860 | January | 20.00 | December | 2.00 |
| 1861 | January | 1.75 | December | .10 |
| 1862 | December | 2.50 | January | .10 |
| 1863 | December | 4.00 | January | 2.00 |
| 1864 | July | 14.00 | February | 3.75 |
| 1865 | January | 10.00 | August | 4.00 |
| 1866 | January | 5.50 | December | 1.35 |
| 1867 | October | 4.00 | June | 1.50 |
| 1868 | July | 5.75 | January | 1.70 |
| 1869 | January | 7.00 | December | 4.25 |
| 1870 | January | 4.90 | August | 2.75 |
| 1871 | June | 5.25 | January | 3.25 |
| 1872 | October | 4.55 | December | 2.67½ |
| 1873 | January | 2.75 | November | .82½ |
| 1874 | February | 2.25 | November | .62½ |
| 1875 | February | 1.82½ | January | .75 |
| 1876 | December | 4.23¾ | January | 1.47½ |
| 1877 | January | 3.69⅜ | June | 1.53¾ |
| 1878 | February | 1.87½ | September | .78¾ |
| 1879 | December | 1.28¾ | June | .62⅛ |
| 1880 | June | 1.24⅜ | April | .71¼ |
| 1881 | September | 1.01¼ | July | .72½ |
| 1882 | November | 1.37 | July | .49¼ |
| 1883 | June | 1.24¾ | January | .83¼ |
| 1884 | January | 1.15⅝ | June | .51¼ |
| 1885 | October | 1.12⅝ | January | .68 |
| 1886 | January | .92¼ | August | .59¾ |
| 1887 | December | .90 | July | .54 |
| 1888 | March | 1.00 | June | .71⅜ |
| 1889 | November | 1.12½ | April | .79½ |
| 1890 | January | 1.07⅝ | December | .60¾ |
| 1891 | February | .81⅜ | August | .50 |
| 1892 | January | .64⅛ | October | .50 |
| 1893 | December | .80 | January | 52⅞ |
| 1894 | December | .95¾ | January | .78½ |
| 1895 | April | 2.60 | January | .95¼ |
| 1896 | January | 1.50 | December | .90 |
| 1897 | March | .96 | October | .65 |
| 1898 | December | 1.19 | January | .65 |
| 1899 | December | 1.66 | February | 1.13 |
| 1900 | January | 1.68 | November | 1.05 |
| 1901 | January, Sept. | 1.45 | May | .80 |
| 1902 | December | 1.54 | Jan., Feb., March | 1.15 |
| 1903 | December | 1.90 | Jan., Feb., March, April, May, June, July | 1.50 |
| 1904 | January | 1.85 | July, December | 1.50 |
| 1905 | October | 1.61 | May | 1.27 |
| 1906 | April, May, June, July | 1.64 | Jan., Feb., March, April, Aug., Sept., Oct., Nov., Dec. | 1.58 |
| 1907 | March to Dec., incl. | 1.78 | January | 1.58 |
| 1908 | No change | 1.78 | No change | 1.78 |
| 1909 | Jan., Feb., March | 1.78 | December | 1.43 |
| 1910 | January | 1.43 | June to Dec., incl. | 1.30 |
| 1911 | December | 1.35 | January to December | 1.30 |
| 1912 | December | 2.00 | January | 1.35 |
| 1913 | March to Dec., incl. | 2.50 | January | 2.00 |
| 1914 | January to March, incl | 2.50 | September to Dec., incl. | 1.45 |
| 1915 | December | 2.25 | April to August, incl. | 1.35 |
| 1916 | December | 2.85 | January | 2.25 |
| 1917 | August 22 to Dec. 30 | 3.75 | January 2 to 5, incl. | 2.85 |
| 1918 | Feb. 8 to Dec. 31, incl. | 4.00 | Jan. 1 to Feb. 8, incl. | 3.75 |

## PRICE SCHEDULE FOR CALIFORNIA CRUDE OIL—1919

| Gravity | Price | Gravity | Price |
|---|---|---|---|
| 14 to 17.9 | $1.23 | 35 to 35.9 | $1.57 |
| 18 to 18.9 | 1.24 | 36 to 36.9 | 1.59 |
| 19 to 19.9 | 1.25 | 37 to 37.9 | 1.62 |
| 20 to 20.9 | 1.27 | 38 to 38.9 | 1.65 |
| 21 to 21.9 | 1.29 | 39 to 39.9 | 1.68 |
| 22 to 22.9 | 1.31 | 40 to 40.9 | 1.71 |
| 23 to 23.9 | 1.33 | 41 to 41.9 | 1.74 |
| 24 to 24.9 | 1.35 | 42 to 42.9 | 1.77 |
| 25 to 25.9 | 1.37 | 43 to 43.9 | 1.80 |
| 26 to 26.9 | 1.39 | 44 to 44.9 | 1.83 |
| 27 to 27.9 | 1.41 | 45 to 45.9 | 1.86 |
| 28 to 28.9 | 1.43 | 46 to 46.9 | 1.89 |
| 29 to 29.9 | 1.45 | 47 to 47.9 | 1.92 |
| 30 to 30.9 | 1.47 | 48 to 48.9 | 1.95 |
| 31 to 31.9 | 1.49 | 49 to 49.9 | 1.98 |
| 32 to 32.9 | 1.51 | 50 to 50.9 | 2.01 |
| 33 to 33.9 | 1.53 | 51 to 51.9 | 2.04 |
| 34 to 34.9 | 1.55 | 52 to 52.9 | 2.07 |

## PRICE CHANGES OF CRUDE OIL, MID-CONTINENT FIELD, SINCE 1905

| | |
|---|---|
| 1906 | $0.44 |
| 1907 | .40 |
| 1908 | .39 |
| 1909 | .36 |
| 1910 | .38 |
| 1911— | |
| January 1 | .44 |
| April | .46 |
| June | .48 |
| September | .50 |
| 1912— | |
| January 2 | .53 |
| January 15 | .55 |
| January 25 | .57 |
| February 5 | .60 |
| April 10 | .62 |
| April 16 | .64 |
| May 7 | .66 |
| May 17 | .68 |
| July 16 | .70 |
| November 3 | .73 |
| November 27 | .76 |
| December 11 | .78 |
| December 16 | .80 |
| December 24 | .83 |
| 1913— | |
| January 27 | .86 |
| January 29 | .88 |
| July 7 | .93 |
| July 21 | .98 |
| August 19 | 1.03 |
| 1914— | |
| February 2 | 1.05 |
| April 8 | 1.00 |
| April 10 | .95 |
| April 13 | .90 |
| April 15 | .85 |
| April 27 | .80 |
| April 29 | .75 |
| September 22 | .65 |
| October 1 | .55 |
| 1915— | |
| February 8 | .45 |
| February 15 | .40 |
| August 2 | .50 |
| August 4 | .55 |
| August 11 | .60 |
| August 19 | .65 |
| August 21 | .75 |
| September 11 | .80 |
| November 13 | .90 |
| November 15 | 1.00 |
| December 13 | 1.10 |
| December 14 | 1.20 |
| 1916— | |
| January 20 | 1.25 |
| January 26 | 1.30 |
| March 4 | 1.40 |
| March 11 | 1.45 |
| March 14 | 1.55 |
| July 24 | 1.45 |
| July 29 | 1.35 |
| August 1 | 1.25 |
| August 7 | 1.15 |
| August 12 | 1.05 |
| August 15 | .95 |
| August 26 | .90 |
| November 29 | 1.00 |
| December 12 | 1.10 |
| December 18 | 1.20 |
| December 23 | 1.30 |
| December 28 | 1.40 |

## PRICE CHANGES OF CRUDE OIL, MID-CONTINENT FIELD, SINCE 1905—Concluded

| | |
|---|---|
| 1917— | |
| January 3 | 1.50 |
| January 6 | 1.60 |
| January 12 | 1.70 |
| August 3 | 1.85 |
| August 16 | 1.90 |
| August 18 | 2.00 |
| 1918— | |
| March 18 | 2.25 |
| 1919 | 2.25 |

## ACTUAL PRODUCTION BY COMPANIES IN MEXICO

| Companies | 1918 Barrels | 1917 Barrels |
|---|---|---|
| Cia. Pet. La Victoria | ......... | 1,574 |
| Topila Petroleum Company | ......... | 2,000 |
| Cia. Mex. Pet. del Golfo | ......... | 29,993 |
| National Oil Company | ......... | 753,589 |
| Panuco Petro. Maat. (Royal Dutch) | 2,748 | ......... |
| Cia. Exp. de Pet. La Universal | 3,075 | ......... |
| Hispano Mexicana (Tex. Mex. Fuel) | 4,226 | 873 |
| Mexico y Espana | 5,459 | 29,625 |
| Mexican Oil Company | 3,490 | 288,770 |
| Cia. Pet. Monterrey | 25,021 | 24,958 |
| Chijoles Oil Ltd. (R. Dutch) | 25,266 | 1,515 |
| Oil Fields of Mexico | 29,906 | 34,689 |
| Veracruz Mexico (S. O. N. J.) | 51,716 | 360,258 |
| La Petrolera Poblana | 91,311 | 32,871 |
| Cia. Mex. de Combustible (Pierce Oil) | 300,064 | 60,852 |
| La Corona (Royal Dutch) | 337,603 | 740,576 |
| Transcontinental de Petroleo (Standard Oil N. J.) | 382,029 | 119,315 |
| Panuco Bost. Oil (Atlan. Ref.) | 531,511 | 828,067 |
| Tampascas Oil Company | 578,478 | 174,924 |
| Internat. Pet. (J. H. Hamm'd) | 609,733 | 619,828 |
| Cia. Pet. Tal Vez. (So. O. & T.) | 1,152,063 | 989,561 |
| Tex. Co. of Mex. (Texas Co.) | 1,279,746 | 2,315,433 |
| Cia. Mex. de Petroleo (Mex. Pet. of Calif.) | 1,445,976 | 1,125,702 |
| Cia. Mex. de Pet. La Libertad (Island O. & T.) | 1,550,869 | ......... |
| Mex. Gulf Oil (Gulf Oil Co.) | 1,728,190 | 1,160,794 |
| Cortez Oil Corp. (Port Lobos Pet. Corp.) | 2,161,775 | ......... |
| East Coast Oil (So. Pac. Co.) | 3,457,235 | 3,143,220 |
| Freeport & Mex. F. O. Corp. (Sinclair Gulf) | 4,119,654 | 4,076,982 |
| Penn Mex. Fuel Co. (South Penn Oil) | 6,854,080 | 4,129,296 |
| Cia. Mex. de Pet. El Aguila (Mexican Eagle Oil) | 16,910,646 | 16,922,322 |
| Huasteca Pet. Co. (Mex. Pet. of Delaware) | 20,186,459 | 17,325,171 |
| Totals | 63,828,326 | 55,292,770 |

# Record of All Mexican Operations to Date—1919

**Prepared by Mexican Petroleum Department, Secretary of Industry**
**1 Cubic Meter = 6.29 Barrels**

| Drilled by | Locations | Drilling Feb. 28 1919 | Producing | Potential Daily Prod. in Cub. Met. | Abandoned | Total No. of Wells |
|---|---|---|---|---|---|---|
| La Universal | .. | 1 | 1 | 511.00 | .. | 2 |
| México y Espana | .. | .. | 1 | 626.00 | .. | 1 |
| La Libertad | .. | .. | 1 | 8,000.00 | .. | 1 |
| Cántabros en Pánuco | .. | 1 | .. | ...... | 1 | 2 |
| La Nacional | .. | 1 | .. | ...... | .. | 1 |
| Pánuco Tamesí | 1 | .. | .. | ...... | .. | 1 |
| Alamo de Pánuco | 1 | .. | .. | ...... | 1 | 2 |
| Tux. Ozuluama | .. | 2 | .. | ...... | .. | 2 |
| Pet. Maritima | .. | .. | .. | ...... | 1 | 1 |
| Freeport & Mex | 1 | 4 | 7 | 5,794.90 | 2 | 14 |
| Esfuerzo Tampiqueno | .. | .. | .. | ...... | 1 | 1 |
| El Caimán | .. | .. | .. | ...... | 1 | 1 |
| Pánuco Valley | 2 | .. | 1 | 66.77 | .. | 3 |
| Southern Co. | .. | .. | 1 | 800.00 | .. | 1 |
| Expl. Topila | .. | .. | 1 | 160.00 | .. | 1 |
| La Trasatlántica | 1 | .. | .. | ...... | .. | 1 |
| Pánuco Mahuaves | .. | .. | .. | ...... | 1 | 1 |
| Lluvia de Oro | .. | 1 | .. | ...... | .. | 1 |
| Esfuerza Nacional | 1 | .. | .. | ...... | 1 | 2 |
| Vado Oil Fields | .. | .. | .. | ...... | 1 | 1 |
| La Victoria | .. | .. | 1 | 6.00 | .. | 1 |
| Transcontinental | 3 | 3 | 12 | 15,804.04 | 7 | 24 |
| R. A. Mestres | 3 | .. | .. | ...... | .. | 3 |
| English Oil Co | .. | 2 | 4 | 1,444.00 | 4 | 10 |
| El Espino | .. | 1 | .. | ...... | .. | 1 |
| Pedro Irisari | .. | .. | 1 | 8.00 | .. | 1 |
| Tampascas Oil | .. | 1 | 5 | 713.00 | 1 | 7 |
| National Pet. | .. | 1 | .. | ...... | .. | 1 |
| Gulf Coast Corp | 1 | .. | 4 | 22.69 | 1 | 6 |
| Los Perforadores | .. | .. | 2 | 319.00 | .. | 2 |
| Hispano Mexicana | .. | .. | 1 | 1,600.00 | 2 | 3 |
| Tal Vez, S. A. | 1 | .. | 2 | 1,155.00 | .. | 3 |
| Monterrey, S. A | .. | .. | 1 | 16.00 | .. | 1 |
| International Pet. | 2 | 4 | 3 | 6,661.22 | 8 | 17 |
| Orbananos et al. | 1 | .. | .. | ...... | .. | 1 |
| Márgenes del Pám | .. | 1 | .. | ...... | .. | 1 |
| Pánuco Topila | .. | .. | 1 | 80.00 | .. | 1 |
| El Fénix, S. A | .. | .. | .. | ...... | 1 | 1 |
| Las Dos Estrellas | 1 | .. | .. | ...... | .. | 1 |
| Productora de Pet. | .. | 1 | 1 | 238.50 | 1 | 3 |
| National Oil Co | 1 | .. | 4 | 598.90 | 1 | 6 |
| Mex. National Oil | 1 | .. | .. | ...... | 2 | 3 |
| Zaleta Mar Oil Co | .. | .. | .. | ...... | 1 | 1 |

**RECORD OF ALL MEXICAN OPERATIONS TO DATE, 1919—Continued**

| Drilled by | Locations | Drilling Feb. 28 1919 | Producing | Potential Daily Prod. in Cub. Met. | Abandoned | Total No. of Wells |
|---|---|---|---|---|---|---|
| La Herradura. . . . . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| Continental Mex. . . . . . . . . | .. | .. | 1 | 1,500.00 | 1 | 2 |
| El Indio. . . . . . . . . . . . . . . | .. | 1 | .. | ...... | .. | 1 |
| Lá Oaxaquena. . . . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| Oil Fields of Méx. . . . . . . . | 1 | 1 | 12 | 60.37 | 23 | 37 |
| New England Fuel. . . . . . . . | .. | .. | 4 | 3,900.02 | .. | 4 |
| La Oriental Méx. . . . . . . . . | 1 | .. | .. | ...... | .. | 1 |
| La Esperanza. . . . . . . . . . . | .. | 1 | .. | ...... | .. | 1 |
| Abastecedora. . . . . . . . . . . | 1 | 1 | .. | ...... | 1 | 3 |
| Pánuco Excelsior. . . . . . . . | .. | .. | 1 | 190.00 | .. | 1 |
| Adrian Petroleum. . . . . . . . | 1 | 2 | 1 | 5,000.00 | .. | 4 |
| Cortez Oil Corp. . . . . . . . . . | 2 | .. | 2 | 804.38 | 1 | 5 |
| Inglesa Explot. . . . . . . . . . | .. | 1 | .. | ...... | 1 | 2 |
| Tantoyuca y Anexas. . . . . . | .. | 2 | .. | ...... | .. | 2 |
| A. P. Wiechers. . . . . . . . . . | 5 | .. | .. | ...... | .. | 5 |
| Mex. Pet. del Golfo. . . . . . . | .. | .. | 1 | 95.40 | 1 | 2 |
| La Corona, S. A. . . . . . . . . . | .. | 4 | 10 | 8,095.42 | 12 | 26 |
| Byrd, et al. . . . . . . . . . . . . | .. | 2 | .. | ...... | .. | 2 |
| Oro Mexicano. . . . . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| La Bonanza. . . . . . . . . . . . . | .. | .. | 1 | 16.00 | .. | 1 |
| Am. Fuel Oil. . . . . . . . . . . . | .. | .. | 2 | 802.95 | .. | 2 |
| Topila Petroleum. . . . . . . . . | .. | .. | 1 | 63.60 | .. | 1 |
| Mexican Gulf. . . . . . . . . . . | 2 | 2 | 8 | 22,370.50 | 8 | 20 |
| Tampico Pánuco. . . . . . . . . | 3 | 2 | .. | ...... | 3 | 8 |
| Chijoles Oil. . . . . . . . . . . . | .. | .. | 7 | 154.33 | .. | 7 |
| American Inter. . . . . . . . . . | .. | .. | 1 | 4.77 | 7 | 8 |
| Hispano Amer. . . . . . . . . . . | 1 | .. | .. | ...... | .. | 1 |
| East Coast Oil. . . . . . . . . . | .. | 1 | 17 | 4,561.06 | 9 | 27 |
| Soria y Socios. . . . . . . . . . | .. | 1 | .. | ...... | .. | 1 |
| Texas Co. of Méx. . . . . . . . | 2 | 3 | 10 | 17,072.19 | 2 | 17 |
| Mexican Oil Co. . . . . . . . . . | 1 | .. | 3 | 639.98 | .. | 4 |
| Smith's Oil Co. . . . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| Pan American Oil. . . . . . . . | .. | 1 | 2 | 875.00 | .. | 3 |
| Orillas de Pánuco. . . . . . . . | .. | 1 | .. | ...... | .. | 1 |
| Nuevo León. . . . . . . . . . . . | .. | 1 | 1 | 15.90 | .. | 2 |
| Mex. de Combust. . . . . . . . | 1 | .. | 9 | 5,051.62 | 6 | 16 |
| Hispano Cubana. . . . . . . . . | .. | .. | 1 | 397.00 | .. | 1 |
| M. C. Anderson. . . . . . . . . . | .. | .. | 2 | 22.25 | .. | 2 |
| Piedras Devel. Co. . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| Lot Seventeen Co. . . . . . . . | 1 | .. | 2 | 6.40 | .. | 3 |
| Punta Arena y Anex. . . . . . | .. | .. | .. | ...... | 1 | 1 |
| Comercio de Puebla. . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| La Argentina. . . . . . . . . . . | 1 | .. | .. | ...... | 1 | 2 |
| México Fuel Oil. . . . . . . . . | 1 | 1 | 5 | 367.13 | 2 | 9 |
| Hidalgo Oil Co. . . . . . . . . . | .. | 1 | .. | ...... | .. | 1 |
| El Nayarit. . . . . . . . . . . . . | .. | .. | 1 | 2,000.00 | .. | 1 |
| Financiera de Pet. . . . . . . . | 1 | .. | .. | ...... | .. | 1 |
| Mex. Development. . . . . . . . | .. | .. | .. | ...... | 1 | 1 |
| El Azadón, S. A. . . . . . . . . . | .. | 1 | .. | ...... | 1 | 2 |

## RECORD OF ALL MEXICAN OPERATIONS TO DATE, 1919—Continued

| Drilled by | Locations | Drilling Feb. 28 1919 | Producing | Potential Daily Prod. in Cub. Met. | Abandoned | Total No. of Wells |
|---|---|---|---|---|---|---|
| La Concordia | .. | .. | 1 | ...... | .. | 1 |
| Nueva Bonanza | .. | .. | .. | ...... | 1 | 1 |
| El Aguila, S. A. | 32 | 18 | 55 | 20,590.18 | 284 | 389 |
| Tamiahua Pet. | 2 | 1 | .. | ...... | 4 | 7 |
| Mex. Pet. Co. Cal | 21 | 1 | 33 | 2,497.65 | 36 | 91 |
| Huasteca Pet. Co | 3 | 11 | 4 | 48,553.70 | 19 | 36 |
| Tuxpam Pet. Co | .. | 1 | .. | ...... | .. | 1 |
| Mundacádiz, S. A | .. | 1 | .. | ...... | .. | 1 |
| Juan Casiano Tux | 1 | .. | .. | ...... | .. | 1 |
| Harry Hummel | .. | .. | .. | ...... | 2 | 2 |
| La Tolteca | 1 | .. | .. | ...... | .. | 1 |
| Tampico Oil Ltd | 1 | .. | 4 | 47.00 | 4 | 9 |
| Tampico Oil Co | .. | .. | .. | ...... | 1 | 1 |
| Penn Mex. Fuel | 4 | 22 | 7 | 13,969.35 | 13 | 26 |
| La Equidad | .. | 1 | .. | ...... | .. | 1 |
| Espana, S. A | 1 | .. | .. | ...... | .. | 1 |
| Pet. de Tepetate | 6 | .. | 2 | 21,462.86 | 1 | 9 |
| Consolidada de Pet | .. | 1 | .. | ...... | .. | 1 |
| Eugenio F. Ruiz | .. | 1 | .. | ...... | .. | 1 |
| Seguranza, S. A | .. | 2 | .. | ...... | 1 | 3 |
| La Giralda | .. | .. | 2 | 160.05 | .. | 2 |
| La Meridional | 1 | .. | 1 | 494.52 | .. | 2 |
| Tampiquena-San Javier | .. | 1 | .. | ...... | .. | 1 |
| Tex. Mex. Fuel Oil | .. | .. | 1 | 400.00 | .. | 1 |
| Nacional de Petr | .. | 1 | .. | ...... | .. | 1 |
| Mexican Premier | .. | 1 | .. | ...... | .. | 1 |
| Eureka | 1 | .. | 1 | 1,072.00 | .. | 2 |
| Pánuco Tuxpam | .. | .. | 1 | 223.00 | .. | 1 |
| Sun Oil Co | 1 | .. | 1 | 127.20 | .. | 2 |
| Petrolera Poblana | .. | .. | 1 | 2,400.00 | .. | 1 |
| La Comercial | 2 | .. | 1 | 5.00 | .. | 3 |
| Pánuco Boston | .. | .. | 2 | 1,113.00 | .. | 2 |
| Regiones Pet. Mex | .. | .. | 4 | 3,465.10 | .. | 4 |
| Puebla en Pánuco | 1 | 2 | .. | ...... | 1 | 4 |
| Allison W. Smith | 1 | .. | .. | ...... | .. | 1 |
| Rodolfo H. Rader | 1 | .. | .. | ...... | .. | 1 |
| Capuchinas Oil | .. | 1 | .. | ...... | 1 | 2 |
| Fomento de Chapala | 1 | .. | .. | ...... | .. | 1 |
| Mexican Sinclair | 1 | 5 | 4 | 2,951.00 | 1 | 11 |
| Pet. Agríc. Mex. San José | 1 | 1 | .. | ...... | .. | 2 |
| Scottish Mex. Oil | .. | .. | .. | ...... | 5 | 5 |
| Los Brujos | .. | .. | .. | ...... | 2 | 2 |
| Catopico Oil Co | 1 | .. | .. | ...... | .. | 1 |
| Dos Banderas Oil | .. | 1 | .. | ...... | .. | 1 |
| Clipton & Smith | 1 | .. | .. | ...... | .. | 1 |
| Freggs Oil Co | .. | .. | .. | ...... | 1 | 1 |
| Hidalgo Pet. Co | .. | 1 | .. | ...... | .. | 1 |
| W. H. Miliken | .. | .. | 1 | 3.18 | .. | 1 |
| Ohio Mex. Oil | .. | .. | 1 | 795.00 | .. | 1 |

## RECORD OF ALL MEXICAN OPERATIONS TO DATE, 1919—Concluded

| Drilled by | Locations | Drilling Feb. 28 1919 | Producing | Potential Daily Prod. in Cub. Met. | Abandoned | Total No. of Wells |
|---|---|---|---|---|---|---|
| Producers Oil Co. | 1 | 1 | 2 | 1,224.30 | .. | 4 |
| Río Vista | .. | .. | .. | ...... | 1 | 1 |
| Sims & Bowser | .. | .. | 1 | 79.50 | 1 | 2 |
| Spanish Mex. Oil | .. | 1 | .. | ...... | .. | 1 |
| J. W. Sloan | .. | 1 | .. | ...... | .. | 1 |
| J. R. Sharp | .. | .. | 1 | 39.75 | .. | 1 |
| Tampico Banking | .. | .. | 2 | 2.24 | .. | 2 |
| Tampico Fuel Oil | .. | .. | 1 | 127.20 | .. | 1 |
| Boston Mex. Leasing | .. | .. | 1 | 12,720.00 | .. | 1 |
| H. McKeever | .. | 1 | .. | ...... | .. | 1 |
| Mex. Tex. Pet | .. | .. | .. | ...... | 1 | 1 |
| Tamesí Pet. & Asph | .. | .. | .. | ...... | 2 | 2 |
| Gobiorno de la Fed | .. | .. | 4 | 3.86 | 5 | 9 |
| Fom. del Sureste | .. | 1 | .. | ...... | .. | .. |
| Totals | 131 | 114 | 299 | 253,217.93 | 512 | 1056 |

## LARGE PRODUCERS OF KANSAS—WITH PRODUCTION
### Daily Production in 1918

| Name | Augusta Barrels | Eldorado Barrels | Outside Barrels | Total Barrels |
|---|---|---|---|---|
| Carter Oil Company | 154 | 6,799 | ..... | 6,953 |
| Carter and S. W. Oil Co | ..... | 9,445 | ..... | 9,445 |
| Magnolia Petroleum Company | 3,126 | ..... | ..... | 3,126 |
| Mid-Kansas Oil Company | 2,108 | ..... | ..... | 2.108 |
| Prairie Oil & Gas Co | 747 | 47 | ..... | 794 |
| Tidal Oil Company | ..... | 1,073 | ..... | 1,073 |
| Cosden Oil & Gas Co | 1,562 | ..... | ..... | 1,562 |
| Empire Gas & Fuel Co | 12,041 | 31,376 | ..... | 43,417 |
| Gypsy Oil Company | ..... | 18,812 | ..... | 18,812 |
| Monitor Oil & Gas Co | 1,539 | ..... | ..... | 1,539 |
| Oklahoma Prod. & Ref. Co | 220 | 31 | ..... | 251 |
| Producers' Oil Company | 83 | ..... | ..... | 83 |
| C. B. Shaffer | ..... | 1,502 | ..... | 1,502 |
| Sinclair Oil & Gas Co | ..... | 1,940 | ..... | 1,940 |
| Totals | 21,580 | 71,025 | ..... | 92,605 |
| All other companies | 1,613 | 14,643 | 13,000 | 29,256 |
| | 23,193 | 85,668 | 13,000 | 121,861 |

## PRODUCTION IN MEXICO TO 1919

| Year | Barrels | Year | Barrels |
|---|---|---|---|
| 1901 | 10,345 | 1910 | 3,634,080 |
| 1902 | 40,200 | 1911 | 12,552,798 |
| 1903 | 75,375 | 1912 | 16,558,215 |
| 1904 | 125,625 | 1913 | 25,696,291 |
| 1905 | 251,250 | 1914 | 26,235,403 |
| 1906 | 502,500 | 1915 | 32,910,508 |
| 1907 | 1,005,000 | 1916 | 40,545,712 |
| 1908 | 3,932,900 | 1917 | 55,292,770 |
| 1909 | 2,713,500 | 1918 | 63,828,327 |

## LARGE PRODUCERS IN CALIFORNIA

| Operator | Per Cent of Total Oil | Proved Land Acres | Number Wells |
|---|---|---|---|
| Associated Oil Company | 9.1 | 7,347 | 1,048 |
| Doheny (various companies) | 7.3 | 4,286 | 379 |
| General Petroleum Corporation | 4.3 | 2,584 | 400 |
| Honolulu Consolidated Oil Company | 1.3 | 2,701 | 35 |
| A. T. & S. F. Ry. (oil subsidiaries) | 4.0 | 3,097 | 412 |
| Shell Company of California | 6.8 | 2,442 | 236 |

## LARGE PRODUCERS IN CALIFORNIA—Concluded.

| Operator | Per Cent of Total Oil | Proved Land Acres | Number Wells |
|---|---|---|---|
| So. Pacific Co. (fuel oil department) | 8.5 | 18,267 | 681 |
| Standard Oil Company | 22.6 | 8,187 | 771 |
| Union Oil Company of California | 8.1 | 8,198 | 427 |
| All others | 28.0 | 30,171 | 3,381 |
| Total | 100.0 | 87,280 | 7,770 |

## IMPORTANT OIL COMPANIES OPERATING IN OKLAHOMA, CALIFORNIA, WYOMING, KANSAS AND TEXAS

| Company | Affiliations |
|---|---|
| Amalgamated Oil Co. | The Amalgamated Oil Co., the Arcturus Oil Co. and the Salt Lake Oil Co. are affiliated and controlled by the Associated Oil Co. which in turn is controlled by the Kern Trading & Oil Co., the producing company of the Southern Pacific Railroad. |
| Associated Oil Co. | Controlled by the Kern Trading & Oil Co. |
| Carter Oil Co. | Owned by Standard Oil Co. of New Jersey. |
| Cosden Oil & Gas Co. | Presumably independent. Some of its affiliated companies are Cosden & Co., Cosden Pipeline Co., Glenn Pool Pipeline Co., Union Petroleum Co., Pen-Mar Oil Co. |
| Empire Gas & Fuel Co. | Affiliated with the Empire Refineries, Inc. Is an independent concern. |
| General Petroleum Corp. | An independent company. |
| Gulf Production Co. | Owned by the Gulf Oil Corporation which is considered an independent. |
| Gypsy Oil Co. | Held by Gulf Oil Corporation, an independent. |
| Humble Oil & Ref. Co. | An independent organization. |
| Invincible Oil Co. | This is an independent, so far as known. |
| Kern Trading & Oil Co. | A producing company of the Southern Pacific R. R. |
| McMan Oil Co. | Sold a controlling interest to the Magnolia Petroleum Co. several months ago. |
| Magnolia Petroleum Co. | Commonly known as a Standard Oil Co. |
| Monitor Oil & Gas Co. | An independent company so far as generally known. |
| Ohio Cities Gas Co. | An independent organization. Has a number of subsidiaries, some of which are the Ardmore Refining Co., International Refining Co., Pure Oil Co., Cornplanter Refining Co. and Quaker Oil & Gas Co. |
| Ohio Oil Co. | One of the Standard Oil group. |
| Pan-American Petroleum & Transport Co. | One of the Doheny interest, presumably with no Standard Oil relations. |
| Prairie Oil & Gas Co. | One of the Standard Oil group and was a subsidiary of Standard Oil of New Jersey until it was separated therefrom by dissolution decree of the U. S. Supreme Court in 1911. |
| Producers Oil Co. | Controlled by the Texas Co., 20 per cent of the stock of which the Federal Trade Commission states is owned by the stockholders of different Standard Oil Co. |
| Quaker Oil & Gas Co. | Originally controlled by Pure Oil Co. Now controlled by Ohio Cities Gas Co. |
| Republic Production Co. | A newly organized company in Texas and is believed to be independent. |
| Roxana Petroleum Co. | A subsidiary of the Royal Dutch Shell group. |
| Shell Co. of California | A subsidiary of the Royal Dutch Shell group. |
| Silurian Oil Co. | An independent organization so far as known. |
| Sinclair Oil & Gas Co. | An independent company which has acquired a large number of smaller producers. The Sinclair Oil and Sinclair Gulf are co-interests. |
| Standard Oil Co. (Cal.) | One of the Standard Oil group. |
| Sun Co. | A close corporation and its connection to other companies is not generally known. |
| Tidal Oil Co. | Principally owned by Tidewater Oil Co., some of the stock of which is held by stockholders in the Standard Oil Co., though presumably independent. |
| Wyoming Oil Fields Co. | Supposedly independent. |

# Petroleum Refineries of North America

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **ALABAMA** | | | | |
| Alabama Oil & Development Co... | Mobile | (Bldg.) | | |
| **ARKANSAS** | | | | |
| Ozark Oil & Refining Co.......... | Fort Smith | 1914 | 125,000 | 300 |
| **CALIFORNIA** | | | | |
| Beckett Refining Co.............. | Arroyo Grande | .... | ...... | ..... |
| Associated Oil Co................ | Avon | 1912 | 1,500,000 | 22,000 |
| Union Oil Co. of Calif........... | Avilla | 1895 | 9,250,000* | 17,000 |
| | | (*All Union Oil Plants) | | |
| Phoenix Refining Co.............. | Bakersfield | 1902 | 300,000 | 1,200 |
| Richfield Oil Co................. | Bakersfield | .... | 200,000 | 3,500 |
| Slager Refining Co............... | Bakersfield | .... | 200,000 | 1,200 |
| Standard Oil Co. of Calif........ | Bakersfield | 1914 | ...... | 20,000 |
| Union Oil Co. of Calif........... | Bakersfield | 1895 | ...... | ..... |
| Vulcan Oil Co.................... | Bakersfield | 1901 | ...... | 400 |
| Capital Refining Co.............. | Berkeley | 1900 | ...... | 600 |
| Monarch Oil Refining Co.......... | Berkeley | 1910 | ...... | Idle |
| Pinal Dome Refining Co........... | Betteravis | 1911 | 560,000 | 1,950 |
| Union Oil Co. of Calif........... | Brea | 1895 | ...... | 10,000 |
| Columbian Oil, Asphalt & Ref. Co. | Carpanteria | 1891 | 100,000 | ..... |
| O'Neal Refining Co............... | Casmalia | .... | ...... | ..... |
| Puente Oil Co.................... | Chino | 1892 | 200,000 | 1,000 |
| American Petroleum Co............ | Coalinga | 1912 | 1,250,000 | 10,000 |
| Shell Co. of Calif............... | Coalinga | .... | 225,000 | 2,000 |
| Standard Oil Co. of Calif........ | El Segundo | 1913 | ...... | 40,000 |
| Paraffin Paint Co................ | Emeryville | 1895 | 100,000 | 300 |
| Wilshire Refining Co............. | Fellows | 1912 | 150,000 | 10,000 |
| Ventura Refining Co. (L)......... | Fillmore | 1915 | 650,000 | 6,000 |
| California-Fresno Oil Co......... | Fresno | 1901 | 50,000 | 500 |
| Pacific States Refining Co....... | Fruitvale | 1904 | 50,000 | ..... |
| Anaheim Union Water Co........... | Fullerton | .... | ...... | 500 |
| St. Helens Petroleum Co.......... | Fullerton | .... | ...... | 600 |
| Associated Oil Co................ | Gaviota | 1899 | 530,570 | 10,000 |
| Moore Refining Co................ | Goleta | .... | ...... | ..... |
| California Liquid Asphalt Co..... | Hadley | 1909 | 25,000 | ..... |
| Ensign Baker Refining Co......... | Hadley | 1910 | 43,000 | 1,000 |
| Hanford Oil Refining Co.......... | Hanford | 1913 | 45,000 | 250 |
| King Refining Co................. | Kern River | 1901 | 175,000 | 250 |
| Producers Oil Refining Co........ | Kern River | 1904 | 65,000 | Idle |
| Standard Oil Co.................. | Kern River | 1914 | 98,750,000* | 65,000 |
| | | (*All S. O. Plants in Calif.) | | |
| Buckeye Refining Co.............. | Kern River | 1901 | ...... | ..... |
| Warren Bros. .................... | Kern River | 1914 | 100,000 | 1,500 |
| General Petroleum Co............. | Kerto | 1913 | 10,000 | 100 |
| Amalgamated Oil Co............... | Los Angeles | 1905 | 200,000 | 10,000 |
| Asphaltum & Oil Refining Co...... | Los Angeles | .... | ...... | ..... |
| Atlas Refining Co................ | Los Angeles | 1892 | 75,000 | 600 |
| California Oil & Asphalt Co...... | Los Angeles | 1900 | 15,000 | 450 |
| Continental Oil Co............... | Los Angeles | 1911 | 100,000 | 1,000 |
| Densmore-Stabler Refining Co..... | Los Angeles | 1907 | ...... | 600 |
| Golden State Oil Co.............. | Los Angeles | 1902 | 75,000 | 650 |
| Fairchild Gilmore Wilton Oil Co.. | Los Angeles | 1912 | 40,000 | 700 |
| Guaranty Oil Co.................. | Los Angeles | 1900 | ...... | 700 |
| Huasteca Petroleum Co............ | Los Angeles | .... | ...... | 1,000 |
| Jordan Oil Co.................... | Los Angeles | .... | ...... | ..... |
| Pioneer Roll Paper Co............ | Los Angeles | 1904 | 80,000 | 500 |
| Richfield Oil Co................. | Los Angeles | 1898 | 200,000 | 900 |
| Service Oil & Asphalt Co......... | Los Angeles | 1892 | 100,000 | 800 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| | **CALIFORNIA—Concluded.** | | | |
| Shell Co. (Trumbull Process) | Los Angeles | .... | ...... | 5,000 |
| Southern Refining Co | Los Angeles | 1900 | ...... | 700 |
| Turner Oil Co | Los Angeles | 1914 | 175,000 | 1,150 |
| Union Oil Co. of Calif | Los Angeles | 1895 | ...... | ..... |
| Western Oil Co | Los Angeles | .... | 81,000 | ..... |
| Wilshire Oil Co. (old Atlas) | Los Angeles | 1912 | 150,000 | 1,000 |
| Vernon Oil Co | Los Angeles | .... | 21,000 | 15,000 |
| Yosemite Oil Refining Co | Los Angeles | 1898 | 30,000 | 600 |
| Union Oil Co. of Calif | Maltha | .... | ...... | 3,000 |
| Adeline Con. Road Oil Co | Maricopa | 1913 | 52,000 | 250 |
| Sunset Monarch Oil Co | Maricopa | 1907 | ...... | 1,000 |
| American Oriental Co. (Shell) (L) | Martinez | 1901 | 265,000 | 6,000 |
| Dutch Shell Co. of Calif | Martinez | 1915 | 2,500,000 | 22,500 |
| General Petroleum Co | Mojave | 1914 | ...... | 8,000 |
| Union Oil Co. of Calif | Oleum | .... | ...... | 22,000 |
| Richfield Oil Co | Olinda | .... | ...... | 800 |
| Union Oil Co. of Calif | Orcutt | 1895 | ...... | ..... |
| Sunset Oil & Refining Co | Ostend | 1903 | ...... | 2,000 |
| Producers & Refiners Oil Co | Oil Port | 1906 | ...... | 5,000 |
| Standard Oil Co | Point Richmond | 1902 | ...... | 60,000 |
| Milriff Refining Co | Rodeo | .... | ...... | 500 |
| Warren Bros. | Rodeo | 1903 | 80,000 | 800 |
| San Diego A-1 Refining Co | San Diego | 1911 | 30,000 | 300 |
| Pacific Roofing & Ref. Co | San Francisco | .... | ...... | 300 |
| Prutzman Refining Co | San Francisco | .... | ...... | ..... |
| West Coast Refining Co | San Francisco | .... | ...... | ..... |
| Western Union Oil Co | Santa Maria | .... | ...... | 1,000 |
| Union Oil Co. of Calif | San Pedro | 1885 | ...... | 800 |
| Capital Crude Oil Co | Santa Paula | .... | ...... | 160 |
| El Merito Refining Co | Santa Paula | .... | ...... | Idle |
| Marchus Bros. | Santa Paula | .... | ...... | 200 |
| A. F. Gilmore | Sherman | .... | 150,000 | 1,000 |
| Tulara Refining Co | Tulara | .... | ...... | ..... |
| Amalgamated Oil Co | Vernon | .... | 75,000 | 3,500 |
| Asphaltum Oil & Ref. Co | Vernon | 1896 | 50,000 | 500 |
| British-California Oil Co | Vernon | .... | ...... | 6,000 |
| California Oil & Asphalt Co | Vernon | 1911 | 125,000 | 885 |
| Crescent Refining Co | Vernon | .... | ...... | 500 |
| General Petroleum Co | Vernon | 1913 | 1,500,000 | 20,000 |
| Hercules Oil Refining Co | Vernon | 1900 | 250,000 | 1,000 |
| Jordan Oil Co | Vernon | 1907 | 175,000 | 700 |
| Martin-Holloran Ref. Co | Vernon | .... | ...... | ..... |
| Pioneer Paper Co | Vernon | .... | ...... | 400 |
| Richfield Oil Co | Vernon | 1907 | 175,000 | 2,000 |
| Turner Oil Co | Vernon | .... | ...... | ..... |
| National Oil Refining Co | Watts | 1906 | 85,000 | 150 |
| G. F. Gilmore Co | Roadamite | .... | ...... | 1,000 |
| | **COLORADO** | | | |
| Apex Refining & Drilling Co | Boulder | 1918 | 100,000 | 1,000 |
| The Inland Refinery | Boulder | 1906 | 125,000 | 1,500 |
| Florence Oil Co. (L) | Florence | 1889 | 350,000 | 1,000 |
| United Oil Co. (Standard) | Florence | 1887 | 1,000,000 | 3,000 |
| Urado Oil Co | Unitah Basin | 1917 | 10,000 | 100 |
| | **FLORIDA** | | | |
| Jackson E. R. & Co | Jacksonville | (Bldg.) | 150,000 | 1,500 |
| | **GEORGIA** | | | |
| Atlantic Refining Co | Brunswick | 1919 | 8,000,000 | 10,000 |
| | **IDAHO** | | | |
| Idaho Oil & Refining Co | Pocatello | (Bldg.) | 50,000 | ..... |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **ILLINOIS** | | | | |
| Midland Oil & Ref. Co | Allendale | 1917 | ...... | ..... |
| Barnett Oil & Gas Co | Blue Island | 1913 | 225,000 | 2,400 |
| Erie Oil & Gas Co | Bridgeport | 1912 | 35,000 | 500 |
| Leader Refining Co | Casey | .... | 250,000 | 500 |
| Oil Jobbers Prod. & Ref. Co | Chicago | 1917 | ...... | ..... |
| Johnson Oil & Ref. Co | Chicago Heights | 1916 | 175,000 | 1,000 |
| Republic Oil & Ref. Co | East Moline | 1917 | 500,000 | 2,500 |
| Anderson & Gustafson | East St. Louis | 1916 | 5,000 | 200 |
| Consol. Oil Ref. Co | East St. Louis | 1915 | 35,000 | 300 |
| Indiahoma Refining Co | East St. Louis | 1907 | 1,000,000 | 4,500 |
| St. Clair Gas & Electr. Co | East St. Louis | 1914 | 40,000 | Idle |
| Lubrite Refining Co | East St. Louis | 1918 | 50,000 | 300 |
| Great Northern Ref. Co. (Great Lakes Refineries, Inc.) | Joliet | 1917 | 300,000 | 1,500 |
| Central Refining Co | Lawrenceville | 1908–9 | 3,000,000 | 3,000 |
| Indian Refining Co | Lawrenceville | 1910 | 1,320,000 | 11,000 |
| The Texas Company | Lockport | 1911 | 1,225,000 | 4,000 |
| Inter Ocean Ref. Co | McCook | 1918 | 250,000 | 2,000 |
| Wabash Refining Co. No. 1 and 2 | Robinson | 1907 | 250,000 | 800 |
| Smith Oil & Refining Co | Rockford | 1909 | 75,000 | 300 |
| Roxana Petroleum Corp | Wood River | 1917 | 11,500,000 | 6,000 |
| Standard Oil Co | Wood River | 1912 | 5,000,000 | 25,000 |
| **INDIANA** | | | | |
| Sinclair Oil & Ref. Co | Whiting | (Bldg.) | 10,000,000 | 6,500 |
| Standard Oil Co. of Ind | Whiting | .... | 25,750,000 | 60,000 |
| **IOWA** | | | | |
| Washington Refining Co | Cedar Rapids | (Bldg.) | 90,000 | ..... |
| **KANSAS** | | | | |
| Sinclair Refining Co | Argentine | 1917 | ...... | 4,500 |
| Kanotex Refining Co | Arkansas City | 1906 | 700,000 | 3,000 |
| Lesh Refining Co. (National) | Arkansas City | 1914 | 300,000 | 2,000 |
| Milliken Refining Co. (L) | Arkansas City | 1917 | 1,150,000 | 6,000 |
| Augusta Refining Co | Augusta | 1917 | 200,000 | 3,000 |
| Bliss Oil & Ref. Corp | Augusta | 1917 | 175,000 | 1,200 |
| Walnut River Ref. Co | Augusta | 1916 | 125,000 | 1,500 |
| White Eagle Refining Co | Augusta | 1917 | 2,000,000 | 5,000 |
| Good Eagle Refining Co | Baxter Springs | 1917 | 50,000 | 600 |
| Chanute Refining Co | Chanute | 1907 | ...... | 1,600 |
| Kansas Cooperative Ref. Co. (L) | Chanute | 1906 | 250,000 | 1,000 |
| Sinclair Refining Co | Chanute | 1907 | ...... | 2,200 |
| Uncle Sam Oil Co. (L) | Cherryvale | 1906 | 350,000 | 1,200 |
| Wright Prod. & Ref. Co | Cherryvale | 1917 | 100,000 | 1,000 |
| Kansas Oil Refining Co. (L) | Coffeyville | 1906 | 1,500,000 | 1,800 |
| National Refining Co. (L) | Coffeyville | 1907 | 1,550,000 | 4,600 |
| Sinclair Ref. Co. (Cudahy) (L) | Coffeyville | 1909 | ...... | 4,500 |
| El Dorado Refining Co | El Dorado | 1916 | 250,000 | 2,000 |
| Fidelity Refining Co | El Dorado | 1918 | 30,000 | 2,500 |
| Midland Refining Co | El Dorado | 1917 | 250,000 | 4,000 |
| Railroad Men's Refining Co | El Dorado | 1918 | 100,000 | 1,500 |
| Great Western Pet. Corp. (L) | Erie | 1905 | 750,000 | 1,000 |
| Miller Petroleum Refining Co | Humboldt | 1906 | 73,626 | 1,000 |
| Hutchinson Refining Co | Hutchinson | 1915 | 125,000 | 1,500 |
| Standard Asph. & Ref. Co | Independence | 1909 | 2,750,000 | 3,000 |
| General Refining Co | Kansas City | 1909 | 100,000 | 800 |
| Kansas City Refining Co | Kansas City | 1906 | 300,000 | 2,700 |
| Sinclair Refining Co | Kansas City | 1917 | 500,000 | 5,000 |
| Commonwealth Oil & Ref. Co | Moran | 1905 | 350,000 | 800 |
| Standard Oil Co. of Kansas | Neodesha | 1892 | 7,250,000 | 9,000 |
| O. K. Refining Co. (L) | Niotaze | 1906 | 400,000 | 1,200 |
| H. & H. Refinery Co | Osawatomie | 1919 | 150,000 | 1,000 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **KANSAS—Concluded** | | | | |
| Red Ball Oil & Ref Co. | Ottawa | 1917 | 75,000 | ..... |
| North American Ref. Co. (operated by Smiley Petrol. Co.) | Rosedale | 1915 | 75,000 | 1,000 |
| Cumberland Refining Co. (Quaker Oil Co.) | Wichita | 1919 | 400,000 | 1,000 |
| Golden Rule Refining Co. | Wichita | 1917 | 35,000 | 1,000 |
| Sterling Oil & Refining Co. | Wichita | 1917 | 500,000 | 5,000 |
| Western Refining Co. | Wichita | 1917 | 35,000 | 1,200 |
| Wichita Indep. Oil & Ref. Co. | Wichita | 1914 | 200,000 | 4,000 |
| **KENTUCKY** | | | | |
| Standard Oil Co. | Barbourville | 1916 | 2,500,000 | 10,000 |
| Neha Refining Co. | Compton Jct. | 1917 | 90,000 | 500 |
| Indian Refining Co. | Georgetown | .... | ...... | Idle |
| Kentucky Prod. & Ref. Co. | Irvine | 1917 | 1,500,000 | 30,000 |
| Southern Oil Ref. Co. | Lexington | 1917 | ...... | ..... |
| Melick Refining Co. | Lexington | 1917 | 100,000 | 1,500 |
| Aetna Refining Co. | Louisville | 1917 | 1,100,000 | 3,000 |
| Security Prod. & Ref. Co. | Louisville | 1917 | 1,000,000 | 3,500 |
| Standard Oil Co. of Kentucky | Louisville | (Bldg.) | ...... | ..... |
| Victor Refining Co. | Louisville | 1917 | ...... | 6,000 |
| Oleum Refining Co. | Pryse | 1917 | 125,000 | 1,000 |
| Pioneer Refining Co. | Rodemer | 1918 | 100,000 | 1,000 |
| McCombs Prod. & Ref. Co. | Torrent | 1918 | 100,000 | 1,000 |
| **LOUISIANA** | | | | |
| Federal Oil & Ref. Co. | Alexandria | 1915 | 150,000 | 1,000 |
| Standard Oil Co. | Baton Rouge | 1910 | 6,000,000 | 40,000 |
| Pelican Oil & Ref. Co. | Chalmette | 1915 | 225,000 | 1,200 |
| Red River Refining Co. | Crichton | 1916 | 200,000 | 1,000 |
| Freeport-Mexican Petroleum Corp. | Destrahan | 1916 | 2,000,000 | 2,000 |
| Tar Island Oil & Ref. Co. | Mooringsport | 1918 | 60,000 | 300 |
| Roxana Petroleum Co. | New Orleans | 1918 | 1,500,000 | 5,000 |
| Freeport & Mexican Fuel Oil Corp. | Meraux | 1917 | 1,500,000 | 10,000 |
| Corona Oil Co. (Dutch Shell Co.) | New Orleans | 1916 | 2,000,000 | 10,000 |
| Freeport & Tampico Fuel Oil Corp. | New Orleans | Prop. | ...... | ..... |
| Liberty Oil Co., Ltd. | New Orleans | 1915 | 40,000 | 700 |
| New Orleans Ref. Co. (Dutch Shell) | New Orleans | 1917 | ...... | ..... |
| Union Refining Co. | Oil City | 1918 | 50,000 | 300 |
| Southern Oil Co., Inc. | Plaquemine | 1917 | 20,000 | 500 |
| Louisiana Oil Refining Co. | Shreveport | 1912 | 1,350,000 | 2,500 |
| Superior Oil Works | Malvern (Lewis) | 1919 | 100,000 | 1,000. |
| Great Southern Prod. & Ref. Co. | Shreveport | 1919 | 150,000 | 1,500 |
| Pine Island Refining Co. | Shreveport | 1916 | 50,000 | 300 |
| Caddo Oil Refinery | Shreveport | 1913 | 500,000 | 2,000 |
| Marine Oil & Ref. Co. | Shreveport | 1918 | 300,000 | 1,000 |
| Shreveport Oil Ref. Co. | Shreveport | 1911 | 50,000 | 1,300 |
| Rio Bravo Oil Co. | Welsh | 1907 | 50,000 | 200 |
| **MARYLAND** | | | | |
| Prudential Oil Corp. (L) | Baltimore | 1915 | 3,750,000 | 10,000 |
| Standard Oil Co. of N. J. | Baltimore | .... | 3,750,000 | 10,000 |
| Gasoline Corporation | Curtis Bay | 1917 | 100,000 | Idle |
| Inter-Ocean Oil Co. (L) | E. Brooklyn | 1913 | 250,000 | 1,500 |
| U. S. Asphalt Ref. Co. | E. Brooklyn | 1911 | 1,000,000 | 5,000 |
| Red "C" Oil Mfg. Co. (L) | Highland Town | .... | 350,000 | 725 |
| **MASSACHUSETTS** | | | | |
| Galena-Signal Oil Co. | Boston | .... | ...... | 300 |
| **MICHIGAN** | | | | |
| White Star Oil Co. | Detroit | 1917 | 175,000 | 400 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **MINNESOTA** | | | | |
| Pure Oil Co. | Minneapolis | 1917 | 60,000 | 400 |
| **MISSOURI** | | | | |
| Wilhoit Refining Co. | Joplin | 1914 | 150,000 | 1,000 |
| Evans-Thwing Refining Co. | Kansas City | 1917 | 500,000 | 4,000 |
| North American Ref. Co. | Kansas City | 1917 | 150,000 | 4,000 |
| St. Jos. Viscosity Oil & Ref. Co. | St. Joseph | 1915 | 25,000 | 500 |
| Standard Oil Co. of Indiana | Sugar Creek | 1917 | 3,000,000 | 15,000 |
| **MONTANA** | | | | |
| Dillon Oil Co. | Butte | .... | 50,000 | 250 |
| **NEBRASKA** | | | | |
| Omaha Oil Refining Co. | Omaha | .... | 150,000 | 1,000 |
| **NEW JERSEY** | | | | |
| Columbia Oil Co. of N. Y. | Bayonne | .... | 600,000 | 1,000 |
| Standard Oil Co. of N. J. (L) | Bayonne | 1873 | 37,000,000 | 78,000 |
| Tidewater Oil Co. (L) | Bayonne | 1879 | 33,000,000 | 13,000 |
| Standard Oil Co. of N. J. | Bayway | 1914 | 15,000,000 | 40,000 |
| Vacuum Oil Co., Paving | Bramwell's Pt. | 1917 | 200,000 | 2,000 |
| Warner-Quinlan Asphalt Co. | Carteret | 1916 | 25,000 | 1,000 |
| Valvoline Oil Co. (L) | Edgewater | 1901 | 500,000 | 1,000 |
| Galena-Signal Oil Co. (L) | Elizabeth | 1916 | 500,000 | 1,500 |
| Columbia Refining Co. | Jersey City | ..... | 50,000 | 100 |
| Standard Oil Co. of N. J. (L) | Jersey City | 1871 | 10,000,000 | 15,000 |
| Barber Asphalt Co. | Maurer | .... | ...... | ..... |
| Warner-Quinlan Co. | Maurer | 1916 | 25,000 | 1,000 |
| Vacuum Oil Co. (L) | Paulsboro | 1916 | 3,000,000 | 10,000 |
| **NEW YORK** | | | | |
| Standard Oil Co. of N. Y. (L) | Buffalo | .... | 1,250,000 | 3,500 |
| Mexican Petroleum Co. | Mariners' Harber | 1915 | 350,000 | 3,000 |
| Standard Oil Co. of N. Y. (L) | New York City | 1882 | 55,000,000 | 23,000 |
| Vacuum Oil Co. (L) | Olean | 1882 | 5,000,000 | 12,00 |
| Vacuum Oil Co. (L) | Rochester | .... | 750,000 | ..... |
| Wellsville Refining Co. (L) | Wellsville | 1901 | 664,000 | 1,000 |
| **OHIO** | | | | |
| Canfield Oil Co. | Cleveland | 1907 | 150,000 | 300 |
| Clarke, Fred G., Co. | Cleveland | .... | 200,000 | 1,500 |
| Great Western Oil Co. | Cleveland | .... | 100,000 | 400 |
| Industrial Oil & Ref. Co. | Cleveland | .... | ...... | ..... |
| Lake Carriers Oil Co. | Cleveland | .... | 75,000 | 500 |
| Standard Oil Co. of Ohio | Cleveland | 1870 | 3,500,000 | 8,400 |
| Middle West Refining Co. | Columbus | 1918 | 125,000 | 1,000 |
| National Refining Co. | Findlay | .... | 250,000 | 1,200 |
| Craig Oil Co. | Ironville | 1891 | 250,000 | 1,200 |
| Solar Refining Co. | Lima | 1886 | 2,575,000 | 10,000 |
| National Refining Co. | Marietta | .... | 150,000 | 500 |
| Sterling Oil Works | Marietta | .... | ...... | 400 |
| Ohio Cities Gas Co. (Heath Refineries) | Newark | 1919 | 300,000 | 3,000 |
| Rajah Oil & Ref. Co. | New Middletown | .... | ...... | 80 |
| Paragon Refining Co. | Toledo | 1888 | 4,500,000 | 3,000 |
| Sun Oil Co. | Toledo | .... | 350,000 | 4,000 |
| Oil Refining & Devel. Co. | Urbana | 1917 | ...... | ..... |
| Ohio Valley Ref. Co. | St. Mary's | 1913 | 450,000 | 1,000 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| | **OKLAHOMA** | | | |
| Crystal White Ref. Co. | Allen | 1915 | 25,000 | 1,000 |
| Ardmore Ref. Co. (Ohio Cities) | Ardmore | 1914 | 1,000,000 | 6,000 |
| Cameron Refining Co. | Ardmore | 1917 | 250,000 | 2,000 |
| Chickasha Refining Co. | Ardmore | 1917 | 250,000 | 3,000 |
| Imperial Refining Co. | Ardmore | 1917 | 250,000 | 2,600 |
| Bigheart Petroleum Ref. Co. | Bigheart | 1908 | 100,000 | 1,200 |
| Bixby Oil & Ref. Co. | Bixby | 1917 | 200,000 | 2,000 |
| Economy Oil & Ref. Co. | Blackwell | 1916 | 120,000 | 1,500 |
| Globe Oil & Ref. Co. | Blackwell | 1917 | 175,000 | 1,500 |
| Modern Refining Co. | Blackwell | 1918 | 250,000 | 2,000 |
| Producers & Refiners Corp. | Blackwell | 1916 | 850,000 | 1,850 |
| Boynton Refining Co. | Boynton | 1916 | 250,000 | 2,500 |
| Continental Refining Co. | Bristow | 1914 | 275,000 | 2,000 |
| Oklamade Ref. Co. | Chelsea | 1918 | 50,000 | 300 |
| Great Central Ref. Co. | Claremore | 1917 | 500,000 | 500 |
| American Oil & Tank Line Co. | Cleveland | 1913 | 750,000 | 1,200 |
| Consolidated Ref. Co. | Cleveland | 1913 | 85,000 | 650 |
| Webster Refining Co. | Coalton | 1911 | ...... | ..... |
| Superior Oil Ref. Co. | Covington | 1917 | 150,000 | 1,000 |
| Anderson & Gustafson (Hillman Ref. Co.). | Cushing | 1914 | 27,000 | 600 |
| Chenning Refining Co. | Cushing | 1917 | 20,000 | 450 |
| Consumers Refining Co. (L) | Cushing | 1913 | 1,250,000 | 5,000 |
| Cosden & Co. | Cushing | 1911 | ...... | 2,000 |
| Cushing Acid Works | Cushing | .... | ...... | ..... |
| Cushing Petroleum Prod. Co. | Cushing | 1917 | 30,000 | 450 |
| Dean Oil Co. | Cushing | 1916 | 25,000 | Idle |
| Empire Refineries (Cushing) | Cushing | 1912 | ...... | 4,000 |
| Federal Refining Co. | Cushing | 1917 | 85,000 | 2,000 |
| Illinois Oil Co. | Cushing | 1914 | 175,000 | 2,000 |
| Indian Chief Ref. | Cushing | 1918 | 25,000 | ..... |
| Inland Refining Co. | Cushing | 1917 | 350,000 | 3,000 |
| International Ref. Co. (Ohio Cities Gas Co.). | Cushing | 1915 | 300,000 | 5,000 |
| Occident Oil & Ref. Co. | Cushing | 1916 | 50,000 | 1,000 |
| Peerless Ref. Co. (Empire) | Cushing | 1914 | 651,000 | 3,000 |
| Sinclair Oil & Ref. Co. | Cushing | 1914 | ...... | 6,000 |
| Kay County Refining Co. | Dilworth | 1917 | 95,000 | 700 |
| Central Refining Co. | Drumright | 1917 | 15,000 | 300 |
| Interstate Oil Refining Co. | Drumright | 1917 | 25,000 | ..... |
| Bu-Co Oil & Refining Co. | Enid | 1917 | 10,000 | ..... |
| Champlin Refining Co. | Enid | 1917 | 75,000 | 1,500 |
| Globe Oil & Ref. Co. | Enid | 1917 | 500,000 | 5,000 |
| Oil State Refining Co. | Enid | 1918 | 250,000 | 1,200 |
| Southwestern Oil Corp. | Enid | 1917 | 85,000 | 1,500 |
| Garber Refinery | Garber | 1918 | 100,000 | 600 |
| Gotebo Refining Co. | Gotebo | 1917 | 10,000 | 100 |
| Carbo Oil Refining Co. | Guthrie | 1918 | 100,000 | 1,500 |
| Forty-Sixth Star Ref. Co. | Healdton | 1917 | 150,000 | 2,000 |
| Terminal Refining Co. | Healdton | 1917 | 400,000 | 2,000 |
| Henryetta Refining Co. | Henryetta | 1917 | 10,000 | ..... |
| Osage Refining Co. | Hominy | 1917 | 30,000 | 1,000 |
| Wabash Refining Co. | Hominy | 1917 | 100,000 | 1,500 |
| Southern Refining Co. | Haskell | 1919 | 100,000 | 1,000 |
| Great American Refining Co. | Jennings | 1917 | 600,000 | 3,000 |
| Acme Ref. & Pipe Line Co. | Jennings | 1917 | 250,000 | 2,500 |
| Odessa Oil & Refining Co. | Jennings | 1917 | 100,000 | ..... |
| Republic Refining Co. | Jennings | 1918 | 85,000 | ..... |
| Comanche Oil & Ref. Co. | Lawton | 1917 | 125,000 | 500 |
| Lawton Refining Co. | Lawton | 1916 | 365,000 | 1,550 |
| North Iowa Oil & Ref. Co. | Lawton | 1917 | 50,000 | ..... |
| Birmingham Oil & Gas Co. | Muskogee | 1917 | 1,000,000 | ..... |
| Haskell Refining Co. | Muskogee | 1917 | 150,000 | ..... |
| Muskogee Refining Co. (L) | Muskogee | 1905 | 1,350,000 | 2,100 |
| Nupro Refining Co. | Muskogee | 1917 | 50,000 | 800 |
| Oklahoma Prod. & Ref. Corp. | Muskogee | 1916 | 2,000,000 | 2,000 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| | **OKLAHOMA—Continued** | | | |
| Sinclair Oil & Ref. Co. (Cudahy) | Muskogee | 1905 | ...... | 800 |
| Crescent Refining Co. | Newkirk | 1917 | 200,000 | 3,000 |
| Dilworth Oil & Refining Co. | Newkirk | 1917 | ...... | ..... |
| Ardmore Producing & Refining Co. | New Wilson | 1917 | 350,000 | 2,500 |
| Triangle Oil Refining Co. | New Wilson | 1917 | 35,000 | ..... |
| Carter Oil Co. | Norfolk | 1916 | 3,500,000 | 18,000 |
| Oilton Refining Co. | Oilton | 1917 | 15,000 | 500 |
| Riverside Refining Co. | Oilton | 1918 | 300,000 | 800 |
| Atwood Refining Co. | Oklahoma City | 1915 | 350,000 | 1,250 |
| Capital Refining Co. of Okla. | Oklahoma City | 1915 | 20,000 | 300 |
| Empire Refineries (Okla. Ref. Co.) | Oklahoma City | 1906 | 250,000 | 2,200 |
| Golden Belt Refining Co. | Oklahoma City | 1918 | 200,000 | ..... |
| Home Petroleum Co. (L) | Oklahoma City | 1918 | 1,500,000 | 2,500 |
| Naphth-oil Mfg. Co. | Oklahoma City | 1918 | 80,000 | 300 |
| Sterling Refining Co. | Oklahoma City | 1918 | 200,000 | 1,000 |
| Allied Refining Co. | Okmulgee | 1917 | 250,000 | 1,000 |
| Empire Ref. (American Ref.) (L) | Okmulgee | 1907 | ...... | 4,000 |
| Indiahoma Refining Co. | Okmulgee | 1910 | 1,258,000 | 3,750 |
| Lake Park Refining Co. | Okmulgee | 1915 | 750,000 | 2,000 |
| Okmulgee Prod. & Ref. Co. | Okmulgee | 1916 | 2,125,000 | 2,500 |
| Oneta Refining Co. | Oneta | 1917 | 40,000 | 1,300 |
| Limbocker Oil & Ref. Co. | Paul's Valley | Prop. | 150,000 | 1,000 |
| Osage Mutual Refining Co. | Pawhuska | 1917 | 30,000 | ..... |
| North American Refining Co. | Pemeta | 1915 | 200,000 | 2,50[illegible] |
| Empire Ref. (Ponca Ref. Co.) (L) | Ponca City | 1912 | ...... | 3,50[illegible] |
| Lake Park Refining Co. | Ponca City | 1917 | 150,000 | 2,0[illegible] |
| Marrland Refining Co. | Ponca City | 1918 | 2,500,000 | 2,[illegible] |
| Bison Refining Co. | Quay | 1918 | 125,000 | 1,[illegible] |
| Peoples Refining Co. | Ringling | 1917 | 100,000 | [illegible] |
| Mohawk Refining Co. | Sand Springs | 1917 | ...... | .. |
| Phoenix Refining Co. | Sand Springs | 1913 | 350,000 | 5,0[illegible] |
| Pierce Oil Corporation (L) | Sand Springs | 1913 | 2,750,000 | 9,5[illegible] |
| Wabash Refining Co. | Sand Springs | 1917 | 250,000 | 5,[illegible] |
| Golden Glow Refining Co. (Duluth Refining Co.) | Sapulpa | 1917 | 175,000 | 3,00[illegible] |
| Sapulpa Refining Co. | Sapulpa | 1908 | 2,000,000 | 7,500 |
| Victor Refining Co. | Sapulpa | 1917 | 100,000 | 1,000 |
| Shawnee Refining Co. | Shawnee | 1917 | 100,000 | ..... |
| Mayfield Oil & Ref. Co. | Terlton | 1918 | 25,000 | 1,500 |
| Bliss Oil & Refining Co. | Tulsa | 1917 | 3,000,000 | ..... |
| Brazilian Oil & Refining Co. | Tulsa | 1917 | 100,000 | ..... |
| Constantin Refining Co. | West Tulsa | 1911 | 1,350,000 | 8,000 |
| Consumers Oil & Refining Co. | West Tulsa | 1917 | 340,000 | 1,200 |
| Cosden & Co. (L) | West Tulsa | 1913 | 47,000,000 | 15,000 |
| Federal Refining Co. | Tulsa | 1917 | 50,000 | ..... |
| Jayhawker Refining Co. | Tulsa | 1917 | 100,000 | ..... |
| Mid-Continent Gasoline Co. | West Tulsa | 1916 | 250,000 | 4,000 |
| Phoenix Refining Co. | Tulsa | .... | 300,000 | ..... |
| Pan-American Refining Co. | West Tulsa | 1916 | 2,000,000 | 6,500 |
| The Texas Company | West Tulsa | 1910 | 2,350,000 | 8,500 |
| Uncle Sam Oil Co. (Valley) | West Tulsa | 1906 | 150,000 | 600 |
| Valley Refining Co. | West Tulsa | 1906 | 150,000 | 1,000 |
| Western Products & Ref. Co. | Tulsa | 1917 | 1,000 | ..... |
| White Star Refining Co. | West Tula | 1917 | 100,000 | 1,500 |
| Milliken Ref. Co. (Sinclair) (L) | Vinita | 1910 | ...... | 10,000 |
| Wilson Refining Co. | Wilson | 1917 | 20,000 | 1,000 |
| Canfield Refining Co. | Yale | 1917 | 250,000 | 1,000 |
| Home Oil Refining Co. | Yale | 1916 | 40,000 | 2,000 |
| Liberty Refining Co. | Yale | 1917 | 30,000 | 2,000 |
| Pawnee Bill Oil & Ref. Co. | Yale | 1916 | 125,000 | 1,000 |
| Southern Oil Corporation | Yale | 1915 | 1,000,000 | 5,000 |
| Star Refining Co. | Yale | 1916 | 16,000 | 600 |
| Sun Company | Yale | 1915 | 600,000 | 3,000 |
| Superior Refining Co. | Yale | 1916 | 21,000 | 190 |

L—Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| | **OKLAHOMA—Concluded** | | | |
| Victor Refining Co. | Yale | 1916–17 | 100,000 | 1,000 |
| Webster Oil & Gasoline Co. | Yale | 1915 | 80,000 | 800 |
| Worth Oil & Refining Co. | Yale | 1918 | 125,000 | 250 |
| Yale Oil Refining Co. | Yale | 1916 | 30,000 | 1,000 |
| | **PENNSYLVANIA** | | | |
| Donecker-Hiller Oil Ref. Co. (L) | Allentown | 1917 | 50,000 | 150 |
| Emery Mfg. Co. (L) | Bradford | 1888 | 610,500 | 1,200 |
| Kendall Refining Co. (L) | Bradford | 1882 | 425,000 | 500 |
| Chippewa Refining Co. | W. Bridgewater | 1919 | (Bldg.) | |
| Butler County Oil Ref. Co. (L) | Bruin | 1911 | 600,000 | 800 |
| Valvoline Oil Co. | Butler | .... | ...... | 1,000 |
| East Welbourne Oil Co. (L) | Butler | 1896 | 500,000 | 1,000 |
| Inter-Ocean Oil Co. | Chester | .... | ...... | ..... |
| Manufacturer's Paraffin Co. | Chester | .... | ...... | ..... |
| Clarendon Refining Co. (L) | Clarendon | 1885 | 220,000 | 1,300 |
| Levi Smith, Ltd. | Clarendon | 1890 | 150,000 | 1,050 |
| Tiona Refining Co. (L) | Clarendon | 1886 | 326,000 | 400 |
| Amber Oil & Realty Co. | Clarendon | 1915 | 50,000 | 150 |
| Canfield Oil Co. (L) | Coraopolis | 1897 | 180,000 | 370 |
| Glenshaw Development Co. | Coraopolis | .... | ...... | 600 |
| Pittsburgh Oil Refining Co. (L) | Coraopolis | 1892 | 225,000 | 1,000 |
| Robinson Oil Corporation | Coraopolis | .... | 22,037,000 | ..... |
| Vulcan Oil Refining Co. (L) | Coraopolis | 1900 | 200,000 | 850 |
| ennsylvania Oil Prod. Ref. Co. (L) | Eldred | 1913 | 227,000 | 500 |
| mlenton Refining Co. (L) | Emlenton | 1891 | 500,000 | 500 |
| erson Oil Works | Erie | .... | ...... | ..... |
| ted Oil Manufacturing Co. | Erie | .... | ...... | ..... |
| ntic Ref. Co. (Eclipse) (L) | Franklin | 1872 | ...... | 8,000 |
| Oil Co. (L) | Franklin | 1917 | 175,000 | 200 |
| klin Quality Ref. Co. (L) | Franklin | 1918 | 100,000 | 100 |
| na-Signal Oil Co. (L) | Franklin | 1869 | 4,500,000 | 2,000 |
| nklin Oil Works (L) | Franklin | 1877 | 20,000 | 300 |
| edom Oil Refining Co. (L) | Freedom | 1889 | 300,000 | 1,500 |
| Refining Co. | Gibson's Point | .... | ...... | 5,000 |
| nnsylvania Refining Co. (L) | Karnes City | 1901 | 90,000 | 100 |
| tarlight Refining Co. | Karnes City | 1893 | 60,000 | 100 |
| Pure Oil Co. (Ohio Cities Gas Co.) (L) | Marcus Hook | 1890 | 2,500,000 | 4,500 |
| Sun Oil Co (L) | Marcus Hook | .... | 3,500,000 | 6,000 |
| Island Petroleum Co. (L) | Neville Island | 1912 | 150,000 | 1,000 |
| Advance Oil Co. | Oil City | 1917 | 75,000 | 300 |
| Jas. Berry's Sons (L) | Oil City | .... | 550,000 | 2,200 |
| Continental Refining Co. (L) | Oil City | 1885 | 275,000 | 750 |
| Crystal Oil Works | Oil City | 1886 | 250,000 | 800 |
| Independent Refining Co. (L) | Oil City | 1882 | 350,000 | 1,000 |
| Penn-American Oil Co. (L) | Oil City | 1892 | 2,000,000 | 2,500 |
| Sunrise Oil Co. | Oil City | 1917 | 100,000 | ..... |
| Crew Levick Co. | Petty's Island | .... | ...... | ..... |
| W. H. Daugherty & Son Ref. Co. | Petrolia | 1880 | 125,000 | 200 |
| Petrolia Refining Co. | Petrolia | 1890 | 20,000 | 50 |
| Crew Levick Co. Seaboard (Doherty) (L) | Philadelphia | .... | 500,000 | 800 |
| Sunlight Oil & Gasoline Wks. | Philadelphia | .... | ...... | 130 |
| Atlantic Refining Co. (L) | Pittsburgh | 1862 | 57,000,000 | 3,500 |
| Chippena Refining Co. | Pittsburgh | 1917 | ...... | ..... |
| A. D. Millers' Sons Co. (L) | Pittsburgh | 1862 | 1,125,000 | 1,000 |
| Waverly Oil Works (L) | Pittsburgh | 1880 | 650,000 | 650 |
| Atlantic Refining Co. (L) | Point Breeze | 1866 | ...... | 42,000 |
| Coldwater Refining Co. | Raymilton | .... | ...... | ..... |
| Empire Oil Works (L) | Reno | 1886 | 350,000 | 650 |
| Crystal Oil Works (L) | Rouseville | 1886 | 250,000 | 800 |
| Pan-American Refining Co. | Rouseville | 1892 | 2,000,000 | 3,000 |
| Mutual Sales Co. (L) | Russell | 1918 | 75,000 | 200 |
| Amber Oil & Realty Co. | Stoneham | .... | ...... | ..... |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **PENNSYLVANIA—Concluded** | | | | |
| Valvoline Oil Co | Struthers | .... | ...... | ..... |
| Natural Gasoline Co | Tidioute | 1919 | (Bldg.) | |
| Interior Oil & Gas Corporation | Tiona | 1917 | 50,000 | 250 |
| American Oil Works (L) | Titusville | 1888 | 350,000 | 800 |
| Crew Levick (Messimer plant) | Titusville | 1912 | 300,000 | 780 |
| Crew Levick (Pa. Par. Wks.) (L) | Titusville | 1905 | 400,000 | 800 |
| Muir Oil Works | Titusville | .... | ...... | ..... |
| Titusville Oil Works | Titusville | 1876 | 210,000 | 1,000 |
| Fred G. Clarke Co | Warren | .... | 500,000 | ..... |
| Conewango Refining Co | Warren | 1895 | 400,000 | 450 |
| Cornplanter Refining Co. (Ohio Cities Gas Co.) | Warren | 1888 | 1,150,000 | 2,000 |
| Mutual Refining Co. (L) | Warren | 1909 | 166,800 | 500 |
| Ohio Cities Gas Co | Warren | .... | ...... | 1,500 |
| Seneca Oil Works (L) | Warren | 1893 | 350,000 | 560 |
| Crew Levick Co. (Glade Oil Wks.) (L) | Warren | 1885 | 350,000 | 680 |
| United Oil Refining Co. (L) | Warren | 1902 | 425,000 | 500 |
| Superior Oil Works (L) | Warren | 1901 | 275,000 | 400 |
| Warren Refining Co. (L) | Warren | 1890 | ...... | 1,700 |
| Wilburine Oil Works (L) | Warren | 1897 | 1,000,000 | 500 |
| Beaver Refining Co. (L) | Washington | 1890 | 115,000 | 200 |
| **RHODE ISLAND** | | | | |
| Standard Oil Co. of N. Y. | Providence | 1919 | (Bldg.) | |
| **TENNESSEE** | | | | |
| Lookout Oil & Refining Co | Chattanooga | 1917 | 100,000 | 1,500 |
| Dixie Refining Co | Memphis | 1917 | 10,000 | 200 |
| General Ref. & Producing Co | Nashville | 1915 | 30,000 | 400 |
| Dix et al | | 1917 | 75,000 | 300 |
| **TEXAS** | | | | |
| Magnolia Petroleum Co. (L) | Beaumont | 1902 | 6,800,000 | 55,000 |
| United Oil & Ref. Co | Beaumont | 1903 | 200,000 | 2,000 |
| Brown Ard Refining Co | Brownwood | 1918 | ...... | 600 |
| Brownwood Refining Co | Brownwood | 1918 | 40,000 | 600 |
| Carson Oil & Refining Co | Brownwood | 1918 | 25,000 | 600 |
| Gotebo Oil & Refining Co | Brownwood | 1918 | 50,000 | Idle |
| Hall-Mountain Refining Co | Brownwood | 1918 | 75,000 | 1,000 |
| Burkburnett Refining Co | Burkburnett | 1918 | 300,000 | 2,000 |
| Dilman & Wright | Burkburnett | 1918 | ...... | 1,500 |
| Federal Oil & Refining Co | Burkburnett | 1918 | ...... | 2,000 |
| Burkburnett-Victor Ref. Co | Burkburnett | 1918 | ...... | 2,500 |
| Beaver Valley Oil & Ref. Co | Cisco | 1918 | 100,000 | 1,000 |
| Liberty Refining Co | Cisco | 1918 | 50,000 | 1,350 |
| Lone Star Oil & Ref. Co | Coleman | 1918 | 50,000 | 500 |
| Central Oil Co | Corsicana | 1903 | 75,000 | Idle |
| Magnolia Petroleum Co. (1) | Corsicana | 1898 | 600,000 | 5,000 |
| Hercules Petroleum Co | West Dallas | 1918 | 215,000 | 3,600 |
| Oriental Oil Co. (1) (L) | Dallas | 1912 | 500,000 | 3,500 |
| State Refining Co | Dallas | 1919 | 150,000 | ..... |
| The Texas Co | Dallas | 1908 | ...... | 16,000 |
| Dallas Refining Co | DeLeon | 1918 | 300,000 | 3,500 |
| Eastland Oil & Refining Co | Eastland | 1918 | ...... | 600 |
| Great Southern Oil & Ref. Co | Eastland | 1918 | ...... | 1,200 |
| Beaver-Electra Refining Co | Electra | 1918 | 250,000 | 2,000 |
| Electra Refining Co | Electra | 1918 | 100,000 | 2,000 |
| Hercules Refining Co | Electra | 1918 | 125,000 | 2,000 |
| Robert Lignon | El Paso | 1917 | 25,000 | 200 |
| Baltic Refining Co. (Inland Refining Co.) | Fort Worth | 1918 | ...... | 5,000 |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| | TEXAS—Concluded | | | |
| El Dorado Refining Co | Fort Worth | (s) | ...... | 5,000 |
| Evans-Thwing Refining Co | Fort Worth | 1918 | ...... | 5,000 |
| Federal Refining Co | Fort Worth | 1918 (Prop.) | | 2,000 |
| Gulf Refining Co | Fort Worth | 1911 | 1,500,000 | 6,000 |
| Home Oil & Refining Co | Fort Worth | 1919 | ...... | 5,000 |
| Magnolia Petroleum Co | Fort Worth | 1914 | 1,000,000 | 15,000 |
| Panther City Oil & Ref. Co | Fort Worth | (s) | ...... | 1,000 |
| Pierce Oil Corporation | Fort Worth | 1912 | 5,600,000 | 15,000 |
| Southern Oil & Refining Assn. (L) | Fort Worth | 1918 | 100,000 | 500 |
| Texas Producing & Ref. Co | Fort Worth | .... | ...... | 4,000 |
| Star Refining Co | Fort Worth | 1919 | ...... | 1,000 |
| Producers Refining Co. (Empire) | Gainesville | 1915 | 1,500,000 | 13,000 |
| Inland Refining Co | Gorham | .... | ...... | 3,000 |
| Empire Refineries | Houston | .... | ...... | 2,000 |
| Hoffman Oil & Ref. Co. (L) | Houston | 1916 | 150,000 | 1,000 |
| Petroleum Refining Co. (L) | Houston | 1916 | 1,000,000 | 1,000 |
| Sinclair-Gulf Corp. (L) | Houston | 1918 | 2,500,000 | 40,000 |
| Trans-Atlantic Pet. Co. (L) | Houston | 1918 | 150,000 | Idle |
| Globe Refining Co | Humble | 1916 | 10,000 | 150 |
| Humble Oil & Refining Co | Humble | 1916 | 15,000 | 600 |
| Mary Owens Oil Co | Humble | 1917 | 15,000 | Idle |
| Wichita Valley Refining Co | Iowa Park | 1914 | 125,000 | 2,500 |
| Avis Refining Co | Jacksboro | 1915 | 150,000 | 300 |
| Eureka Refining Co. (tar) | La Porte | 1917 | 10,000 | 100 |
| Oriental Oil Co | Oriental | .... | ...... | 600 |
| Seaboard Oil & Refining Co. (L) | Orange | 1917 | 150,000 | ..... |
| Gulf Refining Co | Port Arthur | 1901 | 25,000,000 | 60,000 |
| The Texas Co. (L) | Port Arthur | 1902 | 50,000,000 | 32,000 |
| The Texas Co. (L) | Port Neches | 1906 | ...... | 13,000 |
| Odessa Refining Co. (L) | Ranger | 1918 | 100,000 | 3,600 |
| Ranger Oil & Refining Co | Ranger | .... | ...... | 1,000 |
| Ranger Refining Co | Ranger | 1919 | 350,000 | 1,000 |
| Dixie Oil & Refining Co | San Antonio | 1913 | 240,000 | 700 |
| Eggleston & Todd | San Antonio | 1918 | ...... | 1,200 |
| Humble Oil & Ref. Co. (L) | San Antonio | 1913 | 350,000 | 1,800 |
| Slump Oil Co | Somerset | 1915 | 25,000 | 300 |
| Pierce Oil Corp. (L) | Texas City | 1911 | 2,000,000 | 5,000 |
| Black Diamond Oil Co | Thrall | 1916 | 500,000 | 600 |
| Riverside Oil & Refining Co | Waco | .... | ...... | 1,500 |
| South Bosque Refining Co | Waco | .... | ...... | ..... |
| American Refining Co | Wichita Falls | 1919 | ...... | 3,000 |
| Banker Petroleum & Ref. Co | Wichita Falls | 1918 | ...... | 1,500 |
| Gilliland & Fisher (L) | Wichita Falls | 1918 | 100,000 | 1,200 |
| Lone Star Refining Co | Wichita Falls | 1918 | 250,000 | 2,500 |
| Panhandle Refining Co | Wichita Falls | 1915 | 1,500,000 | 5,000 |
| Power Oil & Refining Co | Wichita Falls | 1918 | 125,000 | 1,000 |
| Ranger Wichita Oil & Ref. Co | Wichita Falls | 1918 | ...... | 2,500 |
| Red River Refining Co | Wichita Falls | .... | ...... | 500 |
| Sunshine State Oil & Ref. Co | Wichita Falls | 1918 | 335,000 | 1,250 |
| Texas Gulf Ref. & Pipeline Co | Wichita Falls | .... | ...... | ..... |
| Victory Refining Co | Wichita Falls | (s) | ...... | 2,700 |
| | UTAH | | | |
| Basin Oil Refining Co | Basin | 1917 | ...... | ..... |
| Utah Refining Co | Salt Lake City | 1907 | 250,000 | 800 |
| Utah Oil & Refining Co | Salt Lake City | 1916 | 1,200,000 | 1,500 |
| White Rock Oil & Ref. Co | Salt Lake City | .... | ...... | ..... |
| Urado Oil Co | Uintah Basin | .... | ...... | ..... |
| Dixie Oil Refining Co | Virginia City | 1918 | 10,000 | 100 |
| | VIRGINIA | | | |
| Gulf Refining Co | Norfolk | 1917 | ...... | ..... |
| Mexican Petroleum Corp | Norfolk | 1917 | ...... | ..... |
| Louisiana Oil Refining Co | Richmond | 1917 | ...... | ..... |

L = Lubricating or Wax Plants.

## PETROLEUM REFINERIES OF NORTH AMERICA—Continued

| Company | Location | Year Built | Approximate Investment | Ap. Barrels Crude Daily |
|---|---|---|---|---|
| **WEST VIRGINIA** | | | | |
| Warner-Quinlan Co. | Cairo | .... | ...... | 400 |
| Ohio Cities Gas Co. | Cabin Creek Jct. | 1917 | 1,500,000 | 4,000 |
| Elk Refining Co. | Falling Rock | 1913 | 100,000 | 800 |
| Petroleum Products Co. | Jacksonburg | .... | ...... | 200 |
| Galena-Signal Oil Co. (L) | Parkersburg | 1896 | 650,000 | 2,000 |
| Standard Oil Co. of N. J. | Parkersburg | 1893 | 1,500,000 | 2,500 |
| Ohio Valley Ref. Co. (L) | St. Mary's | 1913 | 900,000 | 1,000 |
| Indiana Refining Co. | Staunton | 1916 | ...... | ..... |
| **WYOMING** | | | | |
| Mid-West Refining Co. | Casper | 1912 | 25,250,000 | 35,000 |
| Natrona Pipeline & Ref. Co. | Casper | .... | 687,767 | ..... |
| Northwestern Refining Co. | Casper | (Bldg.) | ...... | ..... |
| Standard Oil Co. of Indiana | Casper | 1914 | 3,750,000 | 40,000 |
| Utah-Wyoming Oil Ref. Co. | Casper | .... | ...... | ..... |
| Kinney Oil & Refining Co. | Cheyenne | (Bldg.) | ...... | ..... |
| Northwestern Oil Ref. Co. | Cowley | 1909 | 750,000 | 20,000 |
| Wyatt Oil & Refining Co. | Douglas | 1918 | 175,000 | 500 |
| Colorado-Wyoming Ref. Co. | Douglas | .... | ...... | ..... |
| Idaho-Wyoming Oil Co. | Fossil | .... | ...... | ..... |
| Consumers Oil & Refining Co. | Greybull | 1918 | 30,000 | 3,000 |
| Greybull Refining Co. | Greybull | 1915 | 1,500,000 | 12,000 |
| Standard Oil Co. | Greybull | 1916 | 1,500,000 | 5,000 |
| Mid-West Refining Co. | Greybull | 1915 | 25,000,000 | 10,000 |
| Glenrock Refining Co. | Glenrock | (Bldg.) | ...... | 2,000 |
| Mutual Producing & Ref. Co. | Glenrock | 1918 | 500,000 | 800 |
| Wyoming Refining Co. | Greybull | .... | 800,000 | ..... |
| Western Exploration Co. | Lander | .... | ...... | ..... |
| Wind River Refining Co. | Lander | 1918 | 350,000 | 1,000 |
| Mid-West Refining Co. | Laramie | 1919 | ...... | 5,000 |
| Standard Reserve Oil Co. | Le Roy | .... | 2,221,629 | ..... |
| Riverton-Wyoming Ref. Co. | Riverton | 1918 | 150,000 | 1,000 |
| Wyoming Refining Co. | Thermopolis | .... | ...... | ..... |
| Southwest Oil Co. | Thornton | 1918 | 25,000 | 100 |
| **CANADA** | | | | |
| Imperial Oil Co. (L) | Dartmouth, N.S. | 1918 | 2,500,000 | 3,000 |
| Imperial Oil Co. (L) | Ioco, B.C. | 1914 | 4,000,000 | 3,500 |
| Imperial Oil Co. (L) | Montreal, Que. | 1917 | 2,000,000 | 2,500 |
| Calgary Petroleum Products, Ltd. | Okotoks, Alt. | 1915 | 45,000 | 30 |
| Canada Southern Oil & Ref. Co. | Okotoks, Alt. | 1917 | 35,000 | 25 |
| Southern Alberta Ref., Ltd. | Okotoks, Alt. | 1916 | 45,000 | 30 |
| Canadian Oil Companies, Ltd. (L) | Petrolia | 1909 | 1,500,000 | 800 |
| Canadian Oil Prod. & Ref. Co. (L) | Petrolia | 1919 | 200,000 | 150 |
| British Columbia Ref. Co. | Moody, B. C. | 1902 | 1,000,000 | 500 |
| Continental Oil Co. | Regina, Sask. | .... | 1,000,000 | ..... |
| Imperial Oil Co. (L) | Regina, Sask. | 1916 | 2,000,000 | 2,500 |
| Imperial Oil Co. (L) | Sarnia | 1898 | 25,000,000 | 20,000 |
| British-American Oil Co. (L) | Toronto | 1906 | 1,500,000 | 800 |
| Great Lakes Oil & Ref. Co. (L) | Wallaceburg | 1910 | 200,000 | 250 |
| **MEXICO** | | | | |
| Atlantic Refining Co. (Cia. Refinadores y Productori de Petroleo La Atlantica) | Port Lobos | .... | ...... | 10,000 |
| Texas Co. | Port Lobos | .... | ...... | ..... |
| Mexican Eagle Co., Ltd. | Puerto Minatitlan (Isthmus of Tehauntepec) | 1908 | ...... | 15,000 |
| La Corona Petroleum Co. | Tampico (plans) | .... | ...... | 6,000 |
| Mexican Eagle Oil Co., Ltd. | Tampico (W) | 1914 | ...... | 12,500 |
| Pierce Oil Corporation | Tampico (W-L) | 1896 | ...... | 10,000 |
| Huasteca Petroleum Co. | Tampico | 1915 | ...... | 60,000 |
| Standard Oil Co. (N. J.) | Tampico | 1914 | ...... | 6,000 |
| Texas Co. | Tampico | 1918 | ...... | 6,000 |
| Mexican Eagle Oil Co., Ltd. | Tuxpan | .... | ...... | 5,000 |
| Pierce Oil Corporation | Vera Cruz | .... | ...... | 2,500 |

L = Lubricating or Wax Plants.

# Texas Oil Companies With Production in April, May and June, 1919

| Company and Address. | Production, barrels. |
|---|---|
| Abner Davis, Wichita Falls | 2,350.78 |
| American Reclaim Oil Co., South Houston | 2,796.74 |
| Arlington Oil Company, Arlington | 595.04 |
| Anderson Oil Co., Lawton, Okla. | 3,080.58 |
| A No. 1 Oil Co., Lawton, Okla. | 1,528.49 |
| Adams, Brown & McAlister, Wichita Falls | 37,783.83 |
| Abilene-Brownwood Oil Co., Abilene | 251.04 |
| Anna Zip Oil Association, Brownwood | 1,994.59 |
| Allday Oil Co., Wichita Falls | 1,761.72 |
| Art Oil Co., Wichita Falls | 1,383.13 |
| Arcade Oil Co., Beaumont | 763.46 |
| Aikin, L. H., San Antonio | 1,533.22 |
| Adams Oil Co., Wichita Falls | 12,868.68 |
| Amalgamated Oil Co., Wichita Falls | 3,856.28 |
| Ada Bell Oil Co., Independence, Kan. | 20,154.65 |
| Acorn Oil Co., Beaumont | 6,823.58 |
| Annox Oil Co., Beaumont | 14.18 |
| Apple, Dunlap & Sykes, Ardmore, Okla. | 7,805.83 |
| Abernathy Oil & Gas Co., Wichita Falls | 1,833.15 |
| Burk-Star Oil Co., Wichita Falls | 4,773.30 |
| Bartles & Jones, Ranger | 520.00 |
| Butler-Harper Oil Association, Lawton, Okla. | 1,402.76 |
| Block Six Oil Co., Frederick, Okla. | 19,103.80 |
| Big Pool Oil Co., Wichita Falls | 11,823.49 |
| Block Twenty Oil Co., Wichita Falls | 5,627.21 |
| Brundage - Hancock Oil Co. No. 2, Wichita Falls | 7,614.30 |
| Bradley Bros. Oil Co., Houston | 5,560.00 |
| Burkburnett - O'Nail Oil Co., Wichita Falls | 1,540.15 |
| Bowers & Witherspoon, Palestine | 987.40 |
| Brown & Jones, Wichita Falls | 160,987.50 |
| Burk-Vernon Oil Co., Wichita Falls | 2,614.61 |
| Burkdell Oil Co., Odell | 971.88 |
| Bernstein, Eli, Dallas | 24.64 |
| Broome Bros., Brownwood | 191.25 |
| Broome Oil Co., Brownwood | 2,077.29 |
| Bullington, Orville, Wichita Falls | 40,886.02 |
| Bishop Evans Oil Co., Wichita Falls | 11,244.43 |
| Brock-Lunday Oil Co., Bowie | 736.00 |
| Big Four Oil Co., Sour Lake | 21,933.91 |
| B. O. O. G. Oil Co., Iowa Park | 861.07 |
| Brazos River Oil Corp., Fort Worth | 92,263.55 |
| Buchanan, S. R., Batson | 20,455.99 |
| Barkley, T. G., Sour Lake | 1,536.29 |
| Big Flow Oil Co., Wichita Falls | 3,334.50 |
| Big Burk Oil & Gas Co., Wichita Falls | 4,841.47 |
| Bradley, E. L., Beaumont | 1,613.00 |
| Burkburnett - Van Cleve Oil Co., Wichita Falls | 1,622.19 |
| Burnett Petroleum Co., Wichita Falls | 12,104.35 |
| B. C. Oil Co., Wichita Falls | 246.12 |
| Big Seven Oil Company, Wichita Falls | 6,622.08 |
| Big Three Oil Company, Wichita Falls | 2,286.18 |
| Brown Oil Co. No. 1, Wichita Falls | 4,150.65 |
| Bowman, S. M., Brownwood | 258.81 |
| Bowman & Williams, Brownwood | 41.76 |
| Burkburnett Oil & Gas Co., Custer City, Okla. | 150.23 |
| Baker Oil Co., Houston | 2,404.00 |
| Burnett-Mann Oil Co. No. 2, Wichita Falls | 192.50 |
| Block Thirty-Six Oil Co., Wichita Falls | 3,411.98 |
| Burgess, Burgess & Chrestman, Dallas | 2,368.25 |
| Burkburnett Production Co., Dallas | 25,679.20 |
| Biggs Oil & Gas Co., McKinney | 1,115.36 |
| B. M. C. Oil Co., Electra | 151.72 |
| Burkburnett Southern Oil Co., Wichita Falls | 2,378.41 |
| Bi-State Oil and Gas Co., Granfield, Okla. | 381.83 |
| Big Burk Oil and Gas Co. No. 1, Wichita Falls | 10,424.73 |
| Big Jahn Oil Co., Beaumont | 106.45 |
| Burk-Electra Petroleum Co., Dallas | 3,769.72 |
| Central Producing Co., Chickasha, Okla. | 5,531.31 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Continued

| Company and Address. | Production, barrels. |
|---|---|
| Chenault, N. B., Wichita Falls | 8,660.59 |
| Connor & Kinnard, Wichita Falls | 22,965.00 |
| Colony School Well Co., Eastland | 66,777.50 |
| Cotton Oil Co., Saratoga | 2,980.18 |
| Cullinan Oil Association, Ardmore, Okla. | 1,366.52 |
| Cochran-Collis Oil Co., Wichita Falls | 448.71 |
| Crosbie, J. E., Tulsa | 9,762.92 |
| Caldwell Oil Co., Oklahoma City | 1,579.74 |
| Curtis, J. S., Davidson, Okla. | 3,649.23 |
| Conner, W. E., Wichita Falls | 10,379.57 |
| Crown Oil & Ref. Co., Houston | 302,065.71 |
| Cain-Marvin Oil Co., Dallas | 1,889.05 |
| Church Oil Co., Corsicana | 1,929.11 |
| Capital Oil & Gas Company, Hereford | 134.56 |
| Canada Oil Co., Wichita Falls | 5,297.03 |
| Cozy Oil Corporation, Wichita Falls | 2,622.86 |
| Cline, W. D. & Co., Wichita Falls | 1,334.61 |
| C. Y. T. Oil Co., Beaumont | 2,198.27 |
| Crowell & Gant, Dallas | 19,972.72 |
| Coalson Bros. & Affleck, Brownwood | 139.44 |
| Castell Oil Co., Houston. | 5,708.15 |
| Cass Oil Co. Wichita Falls | 2,778.08 |
| Centerfield Oil Company, Wichita Falls | 1,611.70 |
| Crescent Oil Co., Wichita Falls | 1,815.19 |
| Clay, J. D., Houston | 4,477.36 |
| Couch Winfrey Oil Company, Wichita Falls | 3,334.00 |
| Cadillac Oil & Gas Co., Denton | 406.50 |
| Castles Oil Co., Corsicana | 2,023.92 |
| Crowell, L. R., Dallas | 27,126.73 |
| Castro, M., Brownwood | 10.00 |
| Dale - Knott Oil Co., Wichita Falls | 240.00 |
| Diplomat Oil Co., Waco. | 4,528.27 |
| Diebel Oil Co., Thrall | 265.00 |
| E. Z. Mark Oil Co., Electra | 351.38 |
| Eclipse Oil Co., Ft. Worth | 5,749.02 |
| Excelsior Oil Co., Wichita Falls | 1,634.99 |
| Davis, L. R., Tulsa | 4,118.32 |
| Davis-Coggins Oil Co., Wichita Falls | 1,020.55 |
| Duggan Oil Co., Dallas | 480.69 |
| Developers Oil & Gas Co., Wichita Falls | 800.49 |
| Drillers Oil & Gas Co., Wichita Falls | 5,842.66 |
| Double Standard Oil Co., Wichita Falls | 111.50 |
| East Batson Oil Co., Batson | 18,843.45 |
| Electra-Burk Oil Co., Electra | 3,910.75 |
| Engel, Hendrickson & Haron, Wichita Falls | 420.00 |
| Eastland Oil & Ref. Co., Dallas | 21,252.56 |
| Eddy Oil Co., Guffey | 738.32 |
| Ellett Oil Co., Wichita Falls | 1,180.62 |
| Elm Hill Oil Co. Corsicana | 662.00 |
| Farabee Oil Co., Wichita Falls | 3,249.68 |
| Findley-Leach Oil Association, Wichita Falls. | 1,442.89 |
| Freedman, Alex, Corsicana | 187.04 |
| Fisher - Parker Oil Co., Wichita Falls | 1,740.14 |
| Frederick Oil Co., Frederick, Okla. | 2,467.31 |
| Four and Four Oil Co., Dallas | 1,269.17 |
| Farish & Ireland, Houston | 22,130.26 |
| Farqueharson, C. B., Wichita Falls | 6,198.93 |
| Federal Oil Co. of Texas, Cleveland, Ohio | 1,637.00 |
| Findley-Leach, Wichita Falls | 1,442.89 |
| Fisher, Gates & Co., Wichita Falls | 185.75 |
| Fisher & Gilliland, Wichita Falls | 7,618.68 |
| Fowler Farm Oil Co., Wichita Falls | 30,922.52 |
| Findley-Minnick Oil and Gas Co., Benjamine | 6,458.00 |
| Foster-Sander Oil Co., Electra | 1,005.16 |
| Floydada Oil Co., Wichita Falls | 4,872.50 |
| Forest Oil Co., Wichita Falls | 5,338.73 |
| Floyd Oil Co., Electra | 520.00 |
| Fowler, M., Wichita Falls | 961.91 |
| Fritz, D. L., Wichita Falls | 1,498.73 |
| Fritz, L. W., Wichita Falls | 462.35 |
| Gates, F. M., Wichita Falls | 6,432.56 |
| Gusher Oil Co., Wichita Falls | 345.88 |
| Gladstone Oil and Ref. Co., Oklahoma City | 31,274.14 |
| Gulf Coast Oil Corporation, Houston | 110,734.97 |
| Ginsite Oil Co., Frederick, Okla. | 17,577.54 |
| Gatlin, Mrs. M. W., San Antonio | 54.12 |
| Gilbert Co., Beaumont | 7,672.58 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Continued

| Company and Address. | Production, barrels. |
|---|---|
| Guaranty Oil Co., Electra | 851.08 |
| Granite Oil & Gas Co., Electra | 589.34 |
| Gulf Production Co., Houston | 1,999,294.73 |
| Great Dome Oil Co., Wichita Falls | 3,290.50 |
| Grayburg Oil Co., San Antonio | 8,840.01 |
| Gholson, Moorman & Dorsey & Co., Ranger. | 450,980.14 |
| Galconda Oil Co., Wichita Falls | 47,231.00 |
| Goodloe-Kennedy Oil Co., Wichita Falls | 560.00 |
| Gem Oil & Gas Co., Iola, Kans. | 573.91 |
| Harvester Oil Co., Wichita Falls | 20,630.33 |
| Healdton Oil and Gas Co., Wichita Falls | 11,511.32 |
| Hoffman Oil & Ref. Co., Houston | 26,469.44 |
| Houston's Texas Petroleum Co., Houston | 794.64 |
| Hartzell Oil Co., Corsicana | 357.89 |
| Harvey, R. O., lease, Wichita Falls | 26,925.43 |
| Hiawatha Oil Co., Hopkins, Minn. | 117.50 |
| Hereford Oil Co., Hereford | 2,276.35 |
| Houston Oil Co. of Texas, Houston | 11,535.12 |
| Hunt, J. C., Wichita Falls | 1,273.34 |
| Humble Oil and Ref. Co., Houston | 1,490,503.96 |
| Heydrick, J. C., Wichita Falls | 74.53 |
| Herne Oil Co., Wichita Falls | 6,328.75 |
| Hearn Oil Co., Wichita Falls | 7,713.90 |
| Hicks, E. P., Wichita Falls | 12,325.06 |
| Helen-Elizabeth Oil Co., Wichita Falls | 7,446.40 |
| Harvey Oil Co., Wichita Falls | 4,383.62 |
| Hodge Oil Co., Burkburnett | 482.53 |
| Hardin, Willis, Fowler & Staley, Burkburnett | 194.68 |
| Holiday & Gaffall, Beaumont | 2,775.49 |
| Haile Oil Co., Wichita Falls | 336.82 |
| High Land Oil & Gas Co., Electra | 908.34 |
| Hollingsworth, W. E., Brownwood | 302.00 |
| Hall Bros. Oil Co., Brownwood | 1,051.00 |
| Imperial Petroleum Co., Wichita Falls | 27,493.18 |
| Ilsong-Worth Oil Co., Wichita Falls | 13,471.39 |
| Itex Oil Co.. Wichita Falls | 6,105.71 |
| Invincible Oil Co., Houston | 60,005.81 |
| Independent Oil Co., Thrall | 58.64 |
| Jones, Cham, Waurika, Okla. | 379.00 |
| Julia Oil Co., Sour Lake | 4,296.67 |
| Jones, Roy B., Trustee, Wichita Falls | 4,195.68 |
| Junior Oil and Pipeline Co., Corsicana | 432.47 |
| Jackson, J. S., Trustee, Sour Lake | 1,980.81 |
| Janellen Oil Co. Tulsa, Okla. | 2,634.06 |
| John and Jeff Oil Co., Wichita Falls | 5,245.38 |
| Jones-Light Petroleum Co., Pilot Point | 1,399.90 |
| Jacks, A. L. & Co., Benavides | 824.00 |
| Kirby Oil Association, Ellis | 6,063.52 |
| Keever & Gordon Oil Co., Beaumont | 387.00 |
| Kribs Oil Co., Wichita Falls | 4,512.23 |
| Knotts, F. F., Wichita Falls | 449.82 |
| Kemp, E. R., Tulsa, Okla. | 12,358.31 |
| K. A. P. Oil Co., Wichita Falls | 1,673.66 |
| Keim, F. D., Wichita Falls | 1,388.00 |
| Knauth Oil Co., Wichita Falls | 1,610.24 |
| Kurz Oil Co., Von Ormy. | 2,190.00 |
| Kerr, T. P., Corsicana | 343.66 |
| Kemp & Farris, Chillicothe | 2,682.40 |
| Lone Star Oil Co., Burkburnett | 8,788.22 |
| Lawton Oil Co., Burkburnett | 59,030.00 |
| Long, R. A., Association, Wichita Falls | 1,213.53 |
| Ligon, Blair & Rowe, Alvarado | 4,516.05 |
| Lake View Oil Co., Sour Lake | 6,042.00 |
| Leon Oil Co., Wichita Falls | 7,302.28 |
| Lone Star Gas Co., Dallas | 8,856.28 |
| Lyle Oil Co., Mineral Wells | 966.00 |
| Lake Oil Co., Beaumont. | 33,147.16 |
| Logan Oil Co., Humble | 1,305.90 |
| Lucky Seven Oil Co., Wichita Falls | 3,764.97 |
| Liberty Oil Association, Wichita Falls | 3,908.16 |
| Lord, C. A. & Co., Beaumont | 1,688.75 |
| Lee-Graham Oil Co., Sour Lake | 5,612.72 |
| Lone Acre Oil Co., Beaumont | 214.83 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Continued

| Company and Address. | Production, barrels. |
|---|---|
| Lucky Six Oil Co., Bangs. | 782.52 |
| L. N. Lockridge, Wichita Falls | 122.00 |
| Leon Valley Oil Co., De Leon | 3,398.00 |
| Liberty Oil & Gas Co., Tulsa, Okla. | 37,278.96 |
| Minta Oil Co., Saratoga. | 979.80 |
| Munger-Verchoyle Oil Co., Dallas | 9,363.40 |
| McElroy Oil Association, Wichita Falls | 3,029.83 |
| Merrimac Oil Co., Beaumont | 868.41 |
| Lary Lou Gile Oil Co., Wichita Falls | 677.91 |
| McMann Oil Co., Wichita Falls | 10,583.60 |
| Mackeckney Oil Co., Wichita Falls | 1,660.08 |
| Minneapolis Oil and Development Co., Minneapolis, Minn. | 154.43 |
| Magnolia Petroleum Co., Dallas | 1,793,296.28 |
| George A. Martin, Humble | 464.00 |
| Levely-Maxwell Oil Co., Wichita Falls | 322.00 |
| Morris & White, Carbon. | 1,712.64 |
| Mills & Garrity, Corsicana | 2,901.55 |
| Morrisey, Shaw & Heydrick, Wichita Falls | 1,419.86 |
| Morrisey, Shaw & Heydrick, Wichita Falls | 553.44 |
| Martin Oil Co., Beaumont | 3,307.85 |
| Minor Oil Co., Beaumont. | 10,373.31 |
| McGoldrick, E. W., Batson | 3,460.63 |
| Mann-Isleng Oil Co., Wichita Falls | 262.70 |
| Maer, W. Newton, Wichita Falls | 1,278.61 |
| Marnet Oil Co., Corsicana | 6,748.12 |
| Morris Oil Co., Wichita Falls | 2,792.74 |
| Minchew Oil Co., Wichita Falls | 5,138.09 |
| Minchew and Street, Wichita Falls | 6,288.56 |
| McNamara Oil Co., Beaumont | 4,220.41 |
| McMann Oil & Gas Co., Tulsa, Okla. | 852,894.41 |
| McLain, Thad, Oil Co., Columbus, Ohio | 2,396.35 |
| Majestic Petroleum Co., Denver, Colo. | 401.04 |
| Michael Murphy Estate, Thrall | 4,871.41 |
| Mid-Kansas Oil and Gas Co., Mineral Wells | 368,035.55 |
| Mennis & Horn, Beaumont | 1,010.19 |
| Mann-Power Oil Co., Wichita Falls | 6,008.67 |
| Mann Oil Co., Wichita Falls | 3,870.68 |
| Mann-Hood Oil Co., Wichita Falls | 1,006.55 |
| Mayfield Adams & Co., Fort Worth | 212.15 |
| Mitchel Petroleum Co., Fort Worth | 579.50 |
| Mid-Texas Oil Co., Wichita Falls | 123.09 |
| Matador Oil and Gas Co., Quanah | 982.00 |
| Minn-Texas Oil Co., Electra | 214.73 |
| Mann-Naber Oil Co., Wichita Falls | 3,114.02 |
| Mann-McPhall Oil & Gas Co., Wichita Falls | 3,421.82 |
| Memphis Petroleum Co., Memphis | 518.48 |
| Mauprine Oil Co., Sour Lake | 86.50 |
| Mayflower Oil Co., Ardmore, Okla. | 1,366.52 |
| Nacona-Burk Oil Co., Burkburnett | 12,306.00 |
| Northern Oil and Gas Co., Humble | 1,542.00 |
| Nutt, Horace, Wichita Falls | 2,330.30 |
| 1919 Oil and Gas Co., Wichita Falls | 3,001.14 |
| National Oil Co., Chickasha, Okla. | 5,767.22 |
| National Oil and Gas Co., Wichita Falls | 3,655.58 |
| Nineteen Oil Co., Beaumont | 886.70 |
| Norton, Lester L., Indianapolis, Ind. | 1,000.00 |
| Ozark Trail Oil Co., Electra | 4,566.61 |
| O'Neil, John, Wichita Falls | 537.00 |
| Odell Oil Co., Wichita Falls | 4,570.00 |
| Oktaha Oil Co., Tulsa, Okla. | 2,792.51 |
| Ohio Fuel Co., Pittsburgh, Pa. | 5,510.08 |
| Osage Oil and Gas Co., Oklahoma City, Okla. | 210.00 |
| Old Dominion Oil Co., Wichita Falls | 88.00 |
| Oriental Oil Co., Dallas | 3,537.83 |
| Old Colony Oil Co., Dayton | 721.99 |
| P. & M. Oil Co., Houston | 201.87 |
| Patterson Oil Co., Brownwood | 1,504.87 |
| Prairie Oil and Gas Co., Independence, Kans. | 1,058,181.41 |
| Palo Pinto Oil Co., Strawn | 40,783.24 |
| Purcell Oil Co., Wichita Falls | 4,783.91 |
| Plainview Oil and Gas Co., Wichita Falls | 6,215.34 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Continued

| Company and Address. | Production, barrels. |
|---|---|
| Peerless Oil Co., Saratoga | 2,934.13 |
| Petroleum Ref. Co., Houston | 103,426.65 |
| Pippin Oil Co., Brownwood | 6,888.52 |
| Possum Hill Oil Co., San Antonio | 800.00 |
| Perkins, J. J., Wichita Falls | 8,492.69 |
| Panhandle Oil Co., Wichita Falls | 2,580.85 |
| Prime Oil Co., St. Jo | 1,282.34 |
| Plains Oil and Gas Co., Ardmore, Okla. | 36,675.00 |
| Paraffine Oil Co., Beaumont | 11,104.66 |
| Paggi Bros. Oil Co., Beaumont | 17,216.43 |
| Palmer Oil Co., Henrietta | 602.00 |
| Peerless Oil Co., Dallas | 5,666.79 |
| Prather, Ad. "Special," Houston | 7,117.31 |
| Parker-Ezzell Oil Co., Wichita Falls | 1,941.12 |
| Primrose Oil Co., Houston | 5,749.31 |
| Pilot Point Oil and Gas Co., Pilot Point | 438.88 |
| Powhatan Oil Co., Houston | 1,028.05 |
| Phillip Bros. Oil Co., Guffey | 3,893.22 |
| Panther Oil Co., Wichita Falls | 12,577.79 |
| Pinto Oil Co., Wichita Falls | 1,275.79 |
| Powell, J. L., Wichita Falls | 719.71 |
| Plainview-Littlefield Oil Co., Littlefield | 8,685.93 |
| Pivote, M. V., Sour Lake | 4,191.67 |
| Pilant Lake Oil and Gas Co., Houston | 1,045.31 |
| Quanah Oil Co., Quanah | 5,325.85 |
| Red River Oil and Gas Co., Bowie | 303.96 |
| Richardson Oil Co., Brownwood | 1,535.76 |
| Robertson, N. A., Lawton, Okla. | 2,097.62 |
| Robertson Petroleum Co., Lawton, Okla. | 39,605.22 |
| Regna Oil Co., Saratoga | 12,408.32 |
| Robertson & Knotts, Wichita Falls | 562.88 |
| Rogers-Martin Oil Co., Brownwood | 608.57 |
| Rowe, M. D., Wichita Falls | 8,754.79 |
| Russell-Sanderson Oil Co., Wichita Falls | 4,536.55 |
| Ream Oil Co., Wichita Falls | 341.88 |
| Roberts & Hill, Wichita Falls | 739.30 |
| Ruyle Farm Oil Co., Wichita Falls | 39,010.25 |
| Reliance Oil Co., Beaumont | 11,846.99 |
| Reynolds Oil Co., Wichita Falls | 421.44 |
| Russell-Mann-Frank Oil Co., Wichita Falls | 4,377.43 |
| Rio Bravo Oil Co., Houston | 60,426.41 |
| Red River Oil Co., Wichita Falls | 18,124.50 |
| Republic Production Co., Houston | 244,015.27 |
| Ryan Petroleum Co., Wichita Falls | 59,187.78 |
| Silurian Oil Co., St. Louis, Mo. | 12,924.49 |
| Slaughter & Hutchinson, Bowie | 100.20 |
| Sinclair Gulf Oil Co., Tulsa, Okla. | 22,786.53 |
| Sinclair Gulf Oil Co. No. 2, Tulsa, Okla. | 43,736.95 |
| Sinclair Gulf Oil Co. No. 3, Tulsa, Okla. | 73,275.77 |
| Skelly, W. G., Tulsa, Okla. | 17,079.72 |
| Sheegog & Co., Chickasha, Okla. | 417.55 |
| Southwestern Petroleum Co., Tulsa, Okla. | 2,632.12 |
| Shelby Oil and Gas Co. (J. E. Crosbie), Tulsa, Okla. | 2,532.41 |
| Swastika Oil Co., Beaumont | 1,418.04 |
| Stratton Oil Co., Wichita Falls | 7,327.93 |
| Sheldon & Woodruff, Electra | 318.20 |
| Shallow Oil Co., Wichita Falls | 186.60 |
| Sextette Oil Co., Lawton, Okla. | 4,671.05 |
| 6666 Oil Co., Wichita Falls | 10,985.70 |
| States Oil Corporation, Eastland | 1,094.73 |
| Spencer Oil Co., Wichita Falls | 7,664.50 |
| South Bosque Petroleum Co., Waco | 852.04 |
| Sixty-Six Oil Co., Wichita Falls | 1,201.90 |
| Sinks, Joel Co., Corsicana | 254.00 |
| Skaggs Oil Co., Wichita Falls | 2,433.40 |
| Sheperd-Conrey Oil Co., Wichita Falls | 1,222.66 |
| Sun Co. (North Texas Division), Dallas | 354,295.06 |
| Somerset Oil Co., San Antonio | 2,380.87 |
| School Block Oil Co., Burkburnett | 7,744.89 |
| Simms, E. F. & Co., Houston | 260,364.10 |
| Superior Oil Co., Superior, Wis. | 854.98 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Continued

| Company and Address. | Production, barrels. |
|---|---|
| Shamrock Oil Co., Wichita Falls | 21,284.28 |
| Sun Co., Beaumont | 127,997.27 |
| Schlicher Oil Co., Sour Lake | 1,434.05 |
| Staley Mashburn Oil Co., Wichita Falls | 4,211.88 |
| Sam Oil Co., Wichita Falls | 2,354.36 |
| Snider, C. W., Wichita Falls | 7,884.89 |
| Speed, C. D., Corsicana | 156.00 |
| Stella Oil Co., Beaumont | 7,928.98 |
| Stephens Oil Co., Sour Lake | 816.92 |
| Sykes, C. E., Ardmore, Okla. | 402.68 |
| Sanders-Taylor Oil Co., Wichita Falls | 8,495.28 |
| Sammies Oil Corporation, Ranger | 313.00 |
| Surenuff Oil Co., Wichita Falls | 4,063.95 |
| Sinclair Gulf Oil Co. (Damon Mound), Houston | 67,142.79 |
| Swensondale Oil Co., Valley Mills | 146,002.95 |
| Sunshine Surety Oil Co., Wichita Falls | 475.00 |
| Silver Lake Oil Co., Abilene | 495.60 |
| Schultz-Britain Oil Co., Seymour | 257.52 |
| Sutherland, W. C., Wichita Falls | 893.58 |
| Southern Petroleum Co., Houston | 23,393.69 |
| San Diego Oil and Gas Co., Alice | 932.00 |
| Stine-Cameron Oil Co., Henrietta | 471.29 |
| Steelsmith, C. A., Electra | 703.88 |
| San Bernard Oil Co., Beaumont | 4,304.49 |
| Saxon Oil Co., Sour Lake | 3,631.37 |
| Snowden, Geo. M., Humble | 542.00 |
| Sutherland Oil Co., Houston | 4,583.96 |
| Thirty-Nine Oil Co., Wichita Falls | 2,620.00 |
| Turner & Sheegog, Wichita Falls | 1,189.50 |
| Thompson Oil Co., Electra | 3,910.75 |
| Thrity-One Oil Co., Lawton, Okla. | 386.54 |
| Trojan Oil Co., Wichita Falls | 6,952.62 |
| Town Line Oil Co., Wichita Falls | 8,367.00 |
| Thirty-Two Oil Association, Wichita Falls | 1,344.15 |
| Tarver Drilling Co., Dallas | 557.69 |
| Thaxton, W. H., Austin | 433.46 |
| Tex-Penn Oil Co., Pittsburgh, Pa. | 149,051.36 |
| Texas-Eastern Oil Co., Buffalo, N. Y. | 153.48 |
| Texas Company Producing Department, Houston | 2,356,166.73 |
| Texas Pacific Coal & Oil Co., Thrall | 1,521,379.67 |
| Tip Top Oil and Mineral Co., San Antonio | 80.20 |
| Tatum & Cunningham, Corsicana | 93.12 |
| Taylor Oil & Gas Co., Taylor | 8,081.88 |
| Texas Dividend Co., Wichita Falls | 203.71 |
| Texas-Electra Co., Dallas | 269.88 |
| Tex-Homa Oil and Refining Co., Wichita Falls | 79,886.18 |
| Triangle Oil Co., Wichita Falls | 3,461.08 |
| T. H. Y. Oil Co., Sour Lake | 1,278.95 |
| Tri-Mutual Oil Co., Rapid City, S. D. | 1,886.94 |
| Theis Oil Co., Sour Lake | 13,534.81 |
| United Petroleum Co., Houston | 2,201.37 |
| United Producers Co., Wichita Falls | 15,292.01 |
| United Oil and Fuel Co., Philadelphia, Pa. | 3,294.02 |
| Unity Oil Co., Beaumont | 18,208.79 |
| United Petroleum Co., Denver, Colo. | 1,445.84 |
| Valley Oil Co., Petrolia | 157.76 |
| Vat Oil Co., Byers | 873.33 |
| Victor Oil Co., Fredericks, Okla. | 7,318.82 |
| Vindicator Oil Co., Wichita Falls | 7,461.68 |
| Van Cleve Oil Co., Fort Worth | 57,641.36 |
| Vertate Oil Co., Dallas | 1,141.15 |
| Virginia Oil Association, Houston | 3,158.48 |
| Victory Petroleum Co., Wichita Falls | 5,605.02 |
| Vernon Oil Co., Wichita Falls | 2,509.26 |
| Valley View Oil Co., Wichita Falls | 2,407.17 |
| Willis Oil Co., Wichita Falls | 1,214.50 |
| Wichita Burk Oil Co., Wichita Falls | 5,423.77 |
| Wichita Southern Oil Co., Wichita Falls | 5,230.06 |
| West Production Co., Houston | 10,403.78 |
| Woods, G. C., Wichita Falls | 17,407.26 |
| Wichita Valley Oil and Gas Co., Wichita Falls | 120.00 |

## TEXAS OIL COMPANIES WITH PRODUCTION IN APRIL, MAY AND JUNE, 1919—Concluded

| Company and Address. | Production, barrels. |
|---|---|
| Wilson-Broach Oil Co., Beaumont | 21,943.43 |
| Weowna Oil Co., Wichita Falls | 28,415.61 |
| Wichita Falls Gas Co., Wichita Falls | 71.56 |
| Walker-Caldwell Producing Co., Dallas | 6,095.69 |
| Witherspoon Oil Co., San Antonio | 3,746.58 |
| Walker-Smith Oil Co., Brownwood | 39.14 |
| West Texas Oil Co., Wichita Falls | 5,435.75 |
| Woodrow-Lee Oil Co., Wichita Falls | 26,073.22 |
| Wichita-Clay Oil Co., Wichita Falls | 780.48 |
| Weiss-Martin Oil Co., Dallas | 677.41 |
| Williams, J. L., Brownwood | 622.00 |
| Welden Oil Co., Saratoga | 13,400.00 |
| Willis, W. T., Wichita Falls | 3,251.67 |
| Wichita Oil Trust Estate, McKinney | 179.00 |
| Westheimer Realty and Mineral Co., Dallas | 34,192.49 |
| Wood-Dale Oil Co., Henrietta | 4,913.32 |
| Watson-Lee Oil Co., Brownwood | 1,307.49 |
| Worth Oil Co., Tulsa, Okla. | 1,475.92 |
| Webber, A., Oil Co., Freeport | 2,028.14 |
| Wichita Oil and Gas Co., Wichita Falls | 2,160.00 |
| Wichita Falls Petroleum Co., Wichita Falls | 11,093.06 |
| Waggoner, J. J., Hamlin | 766.69 |
| Woods Oil Co., Beaumont | 4,014.79 |
| Webb Oil Co., Humble | 4,092.52 |
| Whale Oil Co., Durant, Okla. | 2,512.95 |
| Yount-Lee Oil Co., Sour Lake | 56,114.67 |
| Ramming, R. W., Wichita Falls | 3,880.00 |
| Ramming, Staley & Co., Wichita Falls | 760.00 |
| South Side Oil Co., Wichita Falls | 2,460.00 |
| Staley, Langford & Co., Wichita Falls | 98,377.59 |
| Staley, J. I. & Co., Wichita Falls | 92,111.00 |
| Staley, J. A., Wichita Falls | 8,841.19 |

## STANDARD OIL GROUP

### Refiners and Marketers

| Company | Capitalization | Mkt. Price | Mkt. Value |
|---|---|---|---|
| Anglo-American | $15,000,000 | 25 | $ 75,000,000 |
| Atlantic Refining | 5,000,000 | 1350 | 67,500,000 |
| Borne-Scrymser | 200,000 | 500 | 1,000,000 |
| Chesebrough Mfg. | 1,500,000 | 310 | 4,650,000 |
| Continental Can | 3,000,000 | 655 | 19,650,000 |
| Galena Signal, 2d pfd | 6,000,000 | 107 | 6,420,000 |
| Galena Signal Oil, 1st pfd | 2,000,000 | 125 | 2,500,000 |
| Galena Signal, common | 16,000,000 | 138 | 22,080,000 |
| International Pet. | 6,265,000 | 31 | 38,844,000 |
| Solar Refining | 2,000,000 | 370 | 7,400,000 |
| S. O. of California | 99,373,310 | 282 | 280,232,706 |
| S. O. of Indiana | 30,000,000 | 800 | 240,000,000 |
| S. O. of Kansas | 2,000,000 | 600 | 12,000,000 |
| S. O. of Kentucky | 6,000,000 | 400 | 24,000,000 |
| S. O. of Nebraska | 1,000,000 | 550 | 5,500,000 |
| S. O. of New Jersey | 98,338,300 | 710 | 698,201,930 |
| S. O. of New York | 75,000,000 | 382 | 286,500,000 |
| S. O. of Ohio | 7,000,000 | 525 | 36,750,000 |
| Swan & Finch | 1,450,000 | 100 | 1,450,000 |
| Vacuum Oil | 15,000,000 | 440 | 66,000,000 |

### Producing Companies

| Company | Capitalization | Mkt. Price | Mkt. Value |
|---|---|---|---|
| Ohio Oil Company | 15,000,000 | 386 | 231,000,000 |
| Prairie Oil & Gas Company | 18,000,000 | 750 | 135,000,000 |
| South West Penn | 20,000,000 | 313 | 62,600,000 |
| Washington Oil | 100,000 | 40 | 400,000 |
| Carter Oil Co | 25,000,000 | ... | ......... |

## STANDARD OIL GROUP—Concluded

### Pipe Lines and Carriers

| | | | |
|---|---|---|---|
| Buckeye Pipe Line | 10,000,000 | 100 | 20,000,000 |
| Crescent Pipe Line | 3,000,000 | 36 | 2,160,000 |
| Cumberland Pipe Line | 1,488,851 | 200 | 2,977,600 |
| Eureka Pipe Line | 5,000,000 | 167 | 8,320,000 |
| Illinois Pipe Line | 20,000,000 | 184 | 36,800,000 |
| Indiana Pipe Line | 5,000,000 | 105 | 10,500,000 |
| National Transit | 6,362,500 | 22 | 11,198,000 |
| New York Transit Company | 5,000,000 | 185 | 9,250,000 |
| Northern Pipe Line | 4,000,000 | 112 | 4,480,000 |
| Prairie Pipe Line | 27,000,000 | 300 | 81,000,000 |
| Southern Pipe Line | 10,000,000 | 165 | 16,500,000 |
| South West Penn | 3,500,000 | 100 | 3,500,000 |
| Union Tank Line | 12,000,000 | 130 | 15,600,000 |

| | |
|---|---|
| Total market values, all companies | $2,486,214,236 |
| Market value refining and marketing companies | 1,834,928,636 |
| Market value producing companies | 429,000,000 |
| Market value pipe line and carrying companies | 222,285,600 |

## PRINCIPAL AMERICAN AFFILIATIONS OF ROYAL DUTCH-SHELL PETROLEUM COMBINE

| | |
|---|---|
| Shell Transport & Trading Co., Ltd.—London | $111,880,000 |
| Royal Dutch | 60,750,000 |
| Roxana Petroleum Co.—N. J. | 60,000,000 |
| Roxana Petroleum Co.—Okla. | 8,000,000 |
| Puora Oil Co.—Okla | .......... |
| Turner Oil Co.—Cal. | 500,000 |
| New Orleans Refining Co | 400,000 |
| Shell Co. of California | 45,000,000 |
| Simplex Refining Co.—Cal. | 3,000,000 |
| Valley Pipeline Co.—Cal | 10,000,000 |
| General Asphalt Co. | 31,000,000 |
| Caribbean Petrol. Syndicate—Venezuela | |
| Petrol. Development Co.—Trinidad | |
| Trinidad Lake Petroleum Co.—Trinidad | |
| Bermudez Co., Ltd.—Venezuela | |
| Anglo Saxon Petroleum Co. Ltd.—London | 38,880,000 |
| Mexican Eagle Oil Co., Ltd.—Mexico | 90,000,000 |
| Eagle Oil & Transp. Co. | |
| Anglo Mexican Petrol. Co., Ltd. | |
| Oil Fields of Mexico, Ltd. | |
| Alliance Co. of Mexico. | |
| La Corona Petroleum Co.—Mexico (Tampico-Panuco Oil Flds., Ltd.) | |
| Tampico-Panuco Petrol. Co.—(Holland), Mexico (Tampico-Panuco Val. Ry. Co.) | |
| British-American Oil Co.—Canada (Chjoles Oil Co.) | |
| Shell Co. of Canada | |
| United British and West Indies Petrol. Synd., Ltd. | |

# Casinghead Gasoline Plants (1917)

| | | Capacity, Gallons |
|---|---|---|
| **CALIFORNIA** | | |
| Fellows Gasoline Co. | Fellows, Calif. | |
| **ILLINOIS** | | |
| Vacuum Gasoline Co. | Bridgeport, Ill. | |
| Central Refining Co. | Lawrenceville, Ill. | |
| Warner-Caldwell Oil Co. | Robinson, Ill. | |
| Roxana Petroleum Co. of Oklahoma | Wood River, Ill. | |
| **KANSAS** | | |
| Paul F. Dahlgren | Elgin, Kan. | |
| Rhode Island Oil Co. | Independence Kan. | |
| S. C. Redd | Iola, Kan. | |
| Hygrade Petroleum & Gasoline Co. | Sedan, Kan. | |
| Sedan Gasoline Co. | Sedan, Kan. | |
| **LOUISIANA** | | |
| De Soto Gasoline Co. | Goss, La. | |
| Bayou Gasoline Co. | Oil City, La. | |
| Standard Oil Co. | Trees City, La. | |
| Central Oil & Gasoline Co., Inc. | Vivian, La. | |
| **OHIO** | | |
| Kinkade Oil & Gas Co. | Bremen, Ohio | |
| Marietta Oil Co. | Marietta, Ohio | |
| Jefferson County Oil Co. | Rayland, Ohio | |
| Jefferson Gasoline Co. | Rayland, Ohio | |
| Summerfield Gas Co. | Summerfield, Ohio | |
| Dinsmore & Co. | Washington, Ohio | |
| John Mildren Sons & Co. | Winton, Ohio | |
| **OKLAHOMA** | | |
| Mid-Co. Gasoline Co. | Adair Okla. | |
| T. B. Gasoline Co. | Alluwe, Okla. | 4,000 |
| Hygrade Petroleum & Gasoline Co. | Avant, Okla. | 1,200 |
| Brighton Gasoline Co. | Bald Hill, Okla. | 1,000 |
| Crystal Gasoline Co. | Bald Hill, Okla. | 1,500 |
| Mileage Gasoline Co. | Bald Hill, Okla. | |
| Producers Oil Co. | Bald Hill, Okla. | |
| Sinclair Oil & Gasoline Co. | Bald Hill, Okla. | |
| Twin Hill Gasoline Co. | Bald Hill, Okla. | 600 |
| Akin Gasoline Co. | Bartlesville, Okla. | |
| Mid-Co. Petroleum & Gasoline Co. | Bartlesville, Okla. | |
| Moon Gasoline Co. | Bartlesville, Okla. | |
| Frank Phillips | Bartlesville, Okla. | 2,500 |
| Wolverine Oil Co. | Bartlesville, Okla. | 5,000 |
| Corlis Oil Co. | Bartlesville, Okla. | |
| Mileage Gasoline Co. | Bartlett, Okla. | |
| Smith & Swan Gasoline Co. | Bartlett, Okla. | 600 |
| Chestnut & Smith | Beggs, Okla. | |
| H. F. Wilcox | Beggs, Okla. | |
| Paul F. Dahlgren | Big Heart, Okla. | |
| Whitehall, Donavan, Hayden & Whitehall | Bird Creek, Okla. | |
| Aiken Gasoline Co. | Bixby, Okla. | |
| Livingston Oil Corporation | Bixby, Okla. | |
| Okla. Petroleum & Gasoline Co. | Bixby, Okla. | |
| The Three Gasoline Co. | Bixby, Okla. | |
| S. C. Redd | Bixby, Okla. | |
| H. F. Wilcox | Bixby, Okla. | |
| Boynton Gasoline Co. | Boynton, Okla. | 4,000 |
| Carter Oil Co. | Boynton, Okla. | 3,000 |

## CASINGHEAD GASOLINE PLANTS—Continued

### OKLAHOMA—Continued

| | | Capacity, Gallons |
|---|---|---|
| Hays Gasoline Co | Boynton, Okla. | 1,100 |
| Sterling Gasoline Co | Boynton, Okla. | |
| Arrow Gasoline Co | Broken Arrow, Okla. | 500 |
| Consumers Oil & Refining Co | Broken Arrow, Okla. | |
| Misener Gasoline Co | Broken Arrow, Okla. | 500 |
| Okla. Petroleum & Gasoline Co | Broken Arrow, Okla. | |
| Piedmont Petroleum & Gasoline Co | Broken Arrow, Okla. | 1,100 |
| Altena Oil Co | Chelsea, Okla. | 2,500 |
| Cinco Oil Co | Chelsea, Okla. | 500 |
| Liquefield Petroleum Co | Chelsea, Okla. | 5,000 |
| Okla. Petroleum & Gasoline Co | Chelsea, Okla. | |
| Una Gasoline Co | Chelsea, Okla. | 1,200 |
| Henderson Gasoline Co | Childers, Okla. | 16,000 |
| Whitehall, Donavan, Hayden & Whitehall | Childers, Okla. | |
| Gypsy Oil Co | Cleveland, Okla. | |
| National Products Co | Cleveland, Okla. | |
| Okla. Petroleum & Gasoline Co | Cleveland, Okla. | |
| Sinclair Oil & Gasoline Co | Cleveland, Okla. | |
| B. T. Curley | Coalton, Okla. | 200 |
| Tidal Gasoline Co | Coalton, Okla. | |
| Chestnut & Smith | Cushing, Okla. | |
| Hillman Refining Co | Cushing, Okla. | 500 |
| Magnolia Petroleum Co | Cushing, Okla. | |
| S. C. Redd | Cushing, Okla. | |
| C. B. Shafer | Cushing, Okla. | 600 |
| Standard Oil Co. of Indiana | Cushing, Okla. | |
| Roxana Petroleum Co. of Okla | Cushing, Okla. | |
| Diamond Gasoline Co | Delaware, Okla. | 8,000 |
| Aikin Gasoline Co | Dewey, Okla. | 2,000 |
| Paul F. Dahlgren | Dewey, Okla. | |
| Dewey Portland Cement Co | Dewey, Okla. | 600 |
| Mid-Co. Gasoline Co | Dewey, Okla. | |
| Barmont Oil Co | Drumright, Okla. | 250 |
| Chestnut & Smith | Drumright, Okla. | |
| Consumers Refining Co | Drumright, Okla. | |
| Gypsy Oil Co | Drumright, Okla. | |
| Hesco Gasoline Co | Drumright, Okla. | |
| Imperial Gasoline Co | Drumright, Okla. | 2,000 |
| McMan Gasoline Co | Drumright, Okla. | 600 |
| Mid-Co. Petroleum & Gasoline Co | Drumright, Okla. | |
| Ohio Cities Gasoline Co | Drumright, Okla. | 3,000 |
| Producers Oil Co | Drumright, Okla. | |
| Sinclair Oil & Gasoline Co | Drumright, Okla. | |
| Standard Oil Co. of Indiana | Drumright, Okla. | |
| Tidal Gasoline Co | Drumright, Okla. | |
| Okla. Petroleum & Gasoline Co | Glenn Pool, Okla. | |
| Producers Oil Co | Glenn Pool, Okla. | |
| Sun Gasoline Co | Glenn Pool, Okla. | |
| Tulsa Gasoline Co | Glenn Pool, Okla. | 600 |
| Victor Gasoline Co | Glenn Pool, Okla. | |
| Watkins Oil Co | Glenn Pool, Okla. | |
| Gates Oil Co | Healdton, Okla. | |
| Magnolia Petroleum Co | Healdton, Okla. | 3,000 |
| Superior Oil & Gas Co | Healdton, Okla. | |
| Mileage Gasoline Co | Haskell, Okla. | |
| Okla. Petroleum & Gasoline Co | Haywood Spur, Okla. | |
| Gypsy Oil Co | Jenks Okla. | |
| Oil State Gasoline Co | Jenks, Okla. | 2,500 |
| Okla. Petroleum & Gasoline Co | Jenks, Okla. | |
| Totem Gasoline Co | Jenks, Okla. | |
| Atlas Petroleum Co | Jennings, Okla. | |
| Crosby & Gillespie | Kiefer, Okla. | 9,000 |
| Chestnut & Smith | Kiefer, Okla. | |
| D. W. Franchot & Co | Kiefer, Okla. | 1,000 |
| Glenn Gas Co | Kiefer, Okla. | 1,100 |
| Gypsy Oil Co | Kiefer, Okla. | |
| Victor Gasoline Co | Kelleyville, Okla. | |
| Heva Gasoline Co | Kelleyville, Okla. | |
| Lawton Refining Co | Lawton, Okla. | |
| Continental Gas Compressing Co | Lenapah, Okla. | 1,000 |

## CASINGHEAD GASOLINE PLANTS—Continued

### OKLAHOMA—Concluded

| Company | Location | Gallons Capacity, |
|---|---|---|
| Mileage Gasoline Co | Lost City, Okla. | |
| Marland Refining Co | Mervin Field, Okla. | 3,000 |
| Okla. Petroleum & Gasoline Co | Mohawk, Okla. | |
| National Products Co | Mounds, Okla. | |
| Nine Oil & Gas Co | Maud, Okla. | |
| Chestnut & Smith | Morris, Okla. | |
| Bradstreet & Co | Muskogee, Okla. | 250 |
| De Soto Gasoline Co | Muskogee, Okla. | |
| Goodwell Oil Co | Muskogee, Okla. | 250 |
| Motor Gasoline Co | Muskogee, Okla. | 1,100 |
| Persian Oil Co | Muskogee, Okla. | 250 |
| Red Demon Gasoline Co | Muskogee, Okla. | 800 |
| Sun Gasoline Co | Muskogee, Okla. | |
| Victor Gasoline Co | Muskogee, Okla. | |
| Whitfield Sears Oil Co | Muskogee, Okla. | 250 |
| Childers Gasoline Co | Nowata, Okla. | 500 |
| Tidal Gasoline Co | Nowata, Okla. | |
| Osage Gasoline Co | Ochelata, Okla. | 2,750 |
| Tidal Gasoline Co | Ochelata, Okla. | |
| A. C. F. Gasoline Co | Oilton, Okla. | 2,000 |
| Chieftain Gasoline Co | Oilton, Okla. | |
| B. B. Jones | Oilton, Okla. | 500 |
| Mid-Co. Gasoline Co | Oilton, Okla. | |
| Mid-Co. Petroleum & Gasoline Co | Oilton, Okla. | |
| National Products Co | Oilton, Okla. | |
| Southland Gas Co | Oilton, Okla. | 600 |
| Standard Oil Co. of Indiana | Oilton, Okla. | |
| Kingwood Oil Co | Okmulgee, Okla. | |
| Magnolia Petroleum Co | Okmulgee, Okla. | |
| O. K. Refining Co | Okmulgee, Okla. | |
| Pine Pool Gasoline Co | Okmulgee, Okla. | 600 |
| Southern Gas Co | Okmulgee, Okla. | |
| Tibbins Gasoline Co | Okmulgee, Okla. | 1,000 |
| Mac Betty Gasoline Co | Osage City, Okla. | |
| H. V. Foster | Osage Junction, Okla. | |
| Victor Gasoline Co | Peru, Okla. | |
| Victor Gasoline Co | Preston, Okla. | |
| Marland Chemical Co | Ponca City, Okla. | |
| Marland Gasoline Co | Ponca City, Okla. | |
| Whitehall, Donavan, Hayden & Whitehall | Pumpkin Center, Okla. | |
| Mileage Gasoline Co | Red Fork, Okla. | |
| Arthur Oil Co | Sapulpa, Okla. | 500 |
| Bluff Gasoline Co | Sapulpa, Okla. | 200 |
| Commerce Gasoline Co | Sapulpa, Okla. | 1,000 |
| Max Rhea Gasoline Co | Sapulpa, Okla. | 600 |
| Richards Gasoline Co | Sapulpa, Okla. | 600 |
| Sapulpa Refining Co | Sapulpa, Okla. | |
| W. G. Skelly | Sapulpa, Okla. | |
| Cosden Oil & Gas Co | Shamrock, Okla. | 8,000 |
| Magnolia Gasoline Co | Shamrock, Okla. | |
| Sinclair Oil & Gasoline Co | Shamrock, Okla. | |
| Union Skiatook Gasoline Co | Skiatook, Okla. | |
| Rotary Gasoline Co | Sperry, Okla. | |
| Black Hawk Petroleum Co | Stone Bluff, Okla. | |
| Hygrade Petroleum & Gas Co | Stone Bluff, Okla. | 1,200 |
| Sinclair Oil & Refining Co | Stone Bluff, Okla. | |
| Okla. Petroleum & Gasoline Co | Standard Spur, Okla. | |
| O. G. Bantley | Tamaha, Okla. | |
| The Dallas Co | Tulsa, Okla. | |
| Pulaski Refining Co | Turkey Mountain, Okla. | 700 |
| Silver Gasoline Co | Vega, Okla. | |
| De Soto Gasoline Co | Wann Okla. | 3,000 |
| Mid-Co. Gasoline Co | Wann, Okla. | |
| Okla. Petroleum & Gasoline Co | Wateva, Okla. | |
| Chestnut & Fitzgerald | Watkins, Okla. | 600 |
| Eagle Gasoline Co | Watkins, Okla. | 1,100 |
| Monarch Gasoline Co | Watkins, Okla. | 1,100 |

## CASINGHEAD GASOLINE PLANTS—Concluded

### PENNSYLVANIA

| | |
|---|---|
| Bradford Oil & Gasoline Co | Bell's Camp, Pa. |
| Pennsylvania Gasoline Co | Bradford Pa. |
| B. B. Stroud Co | Bradford Pa. |
| W. H. Miller | Chicora, Pa. |
| Clarendon Gasoline Co | Clarendon, Pa. |
| Clarendon Refining Co | Clarendon, Pa. |
| D. and C. P. McKee | Clintonville, Pa. |
| Jane Oil Co | Emlenton, Pa. |
| Gilmore Gasoline Co | Gilmore, Pa. |
| Kane Gasoline Co | Kane, Pa. |
| C. J. Ritzert Co | St. Joe, Pa. |
| Henry Farm Oil Co | Warren, Pa. |
| Gilmore Gasoline Co | Wafferty Hollow, Pa. |
| Wayne Naptha Co | Waynesburg, Pa. |

### TEXAS

| | |
|---|---|
| Humble Oil & Refining Co | Burkburnett, Tex. |
| Schulz Gasoline Co | Burkburnett, Tex. |
| Forest Oil Co | Electra, Tex. |
| Forest Oil Co | Iowa Park, Tex. |

### WEST VIRGINIA

| | |
|---|---|
| Imperial Oil & Gas Products Co | Hannahdale W. Va. |
| Jas. B. Berry's Sons Co | Sisterville, W. Va. |
| Consumers Refining Co | Waverly, W. Va. |
| Laughner & Fleming | Wellsburgh, W. Va. |

# American Gas Syndicates and Their Holdings (Gas Record 1919)

| Company | City | State |
|---|---|---|
| SOUTHERN CALIFORNIA GAS CO.......<br>Operating at Los Angeles, Glendale, San Bernardino, Gardena, Riverside, Colton, Arlington, Rialto, Beverley Hills, Van Nuys, Tropico, Lankersheim, San Fernando, Eagle Rock and Burbank. | Los Angeles<br>805 Garland Bldg. | California |
| SOUTHERN COUNTIES GAS CO. of Calif...<br>A consolidation of Southern Counties Gas Co., Long Beach (Calif.) Gas Co., and gas properties of the Southern Calif. Edison Co. Serves natural gas to 42 cities of Los Angeles, Orange and San Bernardino counties. | Los Angeles<br>724 S. Spring St. | California |
| W. F. BOARDMAN CO....................<br>Operates Oregon Gas & Electric Co. at Grant's Pass, Medford, Ashland and Roseburg; Ukiah Gas Co., Ukiah, Calif.; Guadalajara Gas Co., Guadalajara, Jalisco, Mexico. | San Francisco<br>718 Mission St. | California |
| CALIFORNIA LIGHT & FUEL CO.........<br>Engineers: Palo Alto (Calif.) Gas Co.; Nevada Gas Co., Tonopah, Nev. | San Francisco<br>626 Pacific Bldg. | California |
| OAST COUNTIES GAS & ELECTRIC CO...<br>Operates at Santa Cruz, Watsonville, Hollister and the Gilroy (Calif.) Gas Vorks, Contra Costa Gas Co., at Marti-z, Pittsburgh, Antioch, Concord, ockett, Calif. | San Francisco<br>454 California St. | California |
| AST VALLEYS GAS & ELECTRIC CO...<br>Operates at Monterey, Pacific Grove, Carmel-by-the-Sea, Salinas, King City, Soledad, Gonzales, Chular. | San Francisco<br>58 Sutter St. | California |
| NORTHERN CALIFORNIA POWER CO....<br>Operates Northern Calif. Power Co., Keswick Electric Power Co., Battle Creek Power Co., Redding Water Co. and Sacramento Valley Power Co. Owns and operates gas plants at Redding, Red Bluff and Willows. | San Francisco<br>995 Market St. | California |
| PACIFIC GAS & ELECTRIC CO...........<br>Supplies gas to over 50 California towns and cities. | San Francisco<br>445 Sutter St. | California |
| NORTHERN COLORADO POWER CO....<br>Operates: Cheyenne (Wyo.) Light, Fuel & Power Co., Boulder (Colo.) Elec. Lt. & Pr. Co., Western Lt. & Pr. Co., Lafayette, Colo. | Boulder | Colorado |
| SOUTHERN UTILITIES CO.............. | Jacksonville | Florida |
| COPLEY GAS & ELEC. SYNDICATE.....<br>Owns: Western United Gas & Elec. Co., operating gas plants at Aurora, Elgin and Joliet; Murpheysboro (Ill.) Water Wks. & Elec. & Gas Light Co.; Southern Ill. Gas Co., Marion, Ill. | Aurora | Illinois |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| ILLINOIS TRACTION SYSTEM (McKINLEY SYND.). Operates: Danville St. Ry. & Light Co., Urbana & Champaign Ry., Gas & Elec. Co., Decatur Ry. & Light Co.; Jacksonville Ry. & Lt. Co.; Jefferson City (Mo.) Lt., Heat & Pr. Co.; Atchison (Kans.) Ry. Lt. & Pr. Co.; Galesburg (Ill.) Gas & Elec. Co.; Citizens Lighting Co., LaSalle, Ill.; Cairo (Ill.) Gas Co.; Clinton (Ill.) G. & E. Co.; Madison County Lt. & Pr. Co., Carlinville, Ill.; Oskalooa (Ia.) Lt. & Fuel Co. | Champaign | Illinois |
| AMERICAN COAL & BY-PRODUCT COKE CO. Operate by-product plants for Dover By-Products Coke Co., Canal Dover, O., Union By-Products Coke Co., Buffalo, N. Y., Geo. W. Niedringhaus and associates, Granite City, Ill. | Chicago 608 S. Dearborn St. | Illinois |
| K. L. AMES SYNDICATE. Owns and operates Jacksonville (Fla.) Gas Co. | Chicago Woman's Temple Bldg. | Illinois |
| GAS & ELECTRIC IMPROVEMENT CO. Operates Austin (Tex.) Gas Lt. Co., Benton Harbor & St. Joseph (Mich.) Gas & Fuel Co.; Ft. Madison (Ia.) Gas Light Co.; Palestine (Tex.) Lt., Ht. & Pr. Co. | Chicago 39 S. LaSalle St. | Illinois |
| H. M. BYLLESBY & CO. Operates: Muskogee Gas & Elec. Co., Muskogee & Ft. Gibson, Okla.; Mobile (Ala.) Electric Co.; Ft. Smith Lt. & Traction Co., Ft. Smith & Van Buren, Ark., NORTHERN STATES POWER CO., Div. Hqrs.—Minneapolis, Fairbault, Stillwater, Mankato, Cannon Falls, Northfield, St. Paul and South St. Paul, Minn., Hudson, Wis. (St. Croix Gas Co.), and Platteville, Wis., Fargo, Grand Forks, Minot, N. D., Galena, Ill., Sioux Falls, S. D.; MOUNTAIN STATES PR. CO. at Kalispell, Mont. and Sandpoint, Idaho, and Newport, Wash.; Tacoma (Wash.) Gas Co.; OKLA. GAS & ELEC. CO., Enid, El Reno and Okla. City; The Ottumka (Ia.) Ry. & Lt. Co.; San Diego (Cal.) Con. Gas & Elec. Co.; Puget Sound Gas Co., Everett, Wash.; OREGON POWER CO., Marshfield, Eugene, Albany, Corvallis, Dallas, Independence, Monmouth, Oregon; the Southwestern General Gas Co., Fort Smith, Ark.; Olympia (Wash.) Gas Co.; WESTERN STATES GAS & ELEC. CO., Stockton, Richmond and Eureka, Calif.; ARKANSAS VALLEY RY. LT. & PR. CO., Pueblo, Victor, Cripple Creek, Rocky Ford, La Junta and Canon City; LOUISVILLE GAS & ELECTRIC CO. | Chicago Cont. & Com'l Bk. Bldg. | Illinois |
| METROPOLITAN GAS & ELECTRIC CO. Owns and operates: Southwestern Gas & Elec. Co., Shreveport, La., and Texarkana, Tex.; Mobile (Ala.) Gas Co.; Central Indiana Gas Co. of Muncie (hdqrs.), Anderson, Marion; Alexandria, Elwood, Fairmount and Hartford City, Ind.; Jackson Co. Lt., Ht. & Pr. Co. of Independence, Mo.; Beaumont (Tex.) Gas Lt. Co.; Seattle | Chicago Harris Trust Bldg. | Illinois |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| (Wash.) Lighting Co.; Mt. Clemens (Mich.) Gas Light Co.; Gainesville (Tex.) Gas & Elec. Co. | | |
| L. E. MYERS CO. Owns Ashland (Wis.) Lt., Pr. & St. Ry. Co. | Chicago Monadnock Blk. | Illinois |
| UNION UTILITIES CO. Control The Indiana Gas Light Co., operating plants at Noblesville and Tipton, Ind. Also, Lewanee County Gas & Electric Co., Vicksburg, Miss. & St. Charles Lighting Co., St. Charles, Mo.; Dubuque (Ia.) Elec. Co.; Northern Ia. Gas & Elec. Co., Hdqrs., Humboldt, Ia., serving 20 towns in Northern Iowa; gas at Eagle Grove. | Chicago 39 S. LaSalle St. | Illinois |
| MIDDLE WEST UTILITIES CO. Controls and operates following gas properties: | Chicago 72 W. Adams St. | Illinois |
| —Illinois Northern Utilities Co. Belvidere, DeKalb, Dixon, Geneseo, Mendota, Morrison, Rock Falls, Sterling and Sycamore, Ill. | Dixon | Illinois |
| —Central Illinois Public Service Co. Beardstown, Charleston, Macomb, Mattoon, Pana, Paris and Taylorville, Ill. | Mattoon | Illinois |
| —Hoopeston (Ill.) Gas & Elec. Co. | | |
| —Interstate Public Service Co. Bedford, Greenfield, New Castle, Seymour and Shelbyville, Ind.; Franklin (Ind.) Water, Light & Power Co.; Central Indiana Lighting Co., Bloomington, Ind. | Indianapolis | Indiana |
| —Central Indiana Lighting Co. | Indianapolis | Indiana |
| —Franklin (Ind.) Water, Lt. & Pr. Co. | | |
| —United Gas & Electric Co. Jeffersonville and New Albany, Ind. | New Albany | Indiana |
| —Twin State Gas & Electric Co. Bennington, Va.; Brattleboro, Va. | Dover | New Hampshire |
| —Michigan Gas & Electric Co. Ishpeming, Negaunee, Houghton and Hancock, Mich. | | |
| —Missouri Gas & Electric Service Co. Lexington, Marshall, Mo. | | |
| —Kentucky Utilities Co. Shelbyville, Ky. | | |
| —Chickasha Gas & Electric Co. | Chickasha | Oklahoma |
| —Michigan Gas & Electric Co. | Three Rivers | Michigan |
| —Nebraska City (Neb.) Utilities Co. | | |
| —Citizens Gas Light Co. | Jackson | Tennessee |
| PUBLIC SERVICE CO. OF NORTHERN ILLINOIS. Gas plants: Evanston, Blue Island, Weber, Morris, Ottawa, Strator, Pontiac and Kankakee. | Chicago 72 W. Adams St. | Illinois |
| NORTH AMERICAN LIGHT & POWER CO. Hold and operate: Adair County Lt., Pr. & Ice Co. and Mo. Ht., Lt. & Pr. Co., of Kirksville, Mo.; Moberly (Mo.) Lt. & Pr. Co.; Huntsville (Mo.) Lt. & Pr. Co.; Boonville (Mo.) Lt., Ht. & Pr Co.; Ardmore (Okla.) City Gas Co.; Durant (Okla.) Consumers Lt. & Pr. Co.; Washington C. H. (O.) G. & E. Co.; Pocatello (Ida.) Gas & Pr. Co.; Waurika (Okla.) Consumers Lt. & Pr. | Chicago 2013 Peoples Gas Bldg. | Illinois |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Co.; Southern Okla. Pipe Line Co., Ardmore, Okla.; Citizens Elec. Co., Higbee, Mo.; La Plata (Mo.) Lt. & Pr. Co. | | |
| UNITED LT. & RYS. CO. (FINANCIAL OFFICE) | Chicago | Illinois |
| UTILITIES DEVELOPMENT CO. | Chicago<br>327 S. LaSalle St. | Illinois |
| WISCONSIN PR. & LT. & HT. CO.<br>Owns Baraboo, Beaver Dam, Berlin. | Chicago<br>72 W. Adams St. | Illinois |
| E. A. POTTER<br>Controls Madison, Ind., Creston, Ia., Junction City, Abilene, Great Bend, and Manhattan, Kansas. | Chicago<br>Rector Bldg. | Illinois |
| J. J. FREY SYNDICATE<br>Owns Southern Illinois Lt. & Pr. Co. and Citizens Gas, Elec. & Htg. Co. Gas plants at Mt. Vernon, Litchfield, and Hillsboro. | Hillsboro | Illinois |
| NORTHERN INDIANA GAS & ELECTRIC CO.<br>Northern Division operates Hammond, Michigan City and South Bend; also, Southern Division operates LaFayette, Lebanon, Logansport, Fort Wayne, Bluffton, Decatur, Frankfort, Crawfordsville, and Wabash;<br>Ohio Division operates Lima, St. Marys, Wapakoneta, Celina, Recovery, Cridersville, and Coldwater. | Hammond | Indiana |
| INTERSTATE PUBLIC SERVICE CO.<br>(Listed above.) | Indianapolis | Indiana |
| W. A. MARTIN GAS SYNDICATE<br>Operates Greencastle (Ind.) Gas & Elec. Co., Rochester Gas & Fuel Co. | Laporte | Indiana |
| CONSOLIDATED GAS & OIL CO.<br>Owns plants at Ridgeville, Red Key and Dunkirk, Ind. | Ridgeville | Indiana |
| IOWA ELECTRIC CO.<br>Operates gas plants at Fairfield, Iowa Falls and Perry; also various electric and railway plants. Under name of Iowa Ry. & Lt. Co. also operates Marshalltown Ia. | Cedar Rapids | Iowa |
| R. K. RUNNER<br>Interested in Austin, Minn.; Charles City, Ia., and Cherokee, Ia. | Charles City | Iowa |
| IOWA GAS & ELEC. CO.<br>Owns gas plants at Mt. Pleasant and Washington, Ia. | Iowa City | Iowa |
| AMERICAN GAS CONSTRUCTION CO.<br>Interested in Ia. Pub. Serv. Co., Ames, Ia.; Citizens Gas Co., Carroll, Ia.; Belle Plaine (Ia.) Gas Co. | Newton | Iowa |
| AMERICAN CITIES CO.<br>Controls: N. O. Ry. & Lt. Co., Birmingham (Ala.) Ry., Lt. & Pr. Co., Houston (Tex.) Ltg. & Pr. Co.; Little Rock Ry. & Elec. Co., Memphis St. Ry. Co., Knoxville Ry. & Lt. Co. | New Orleans<br>201 Baronne St. | Louisiana |
| GENERAL UTILITIES & OPERATING CO.<br>Controls Americus (Ga.) Ltg. Co. and several electric properties. | Baltimore<br>Munsey Bldg. | Maryland |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| COMMONWEALTH GAS & ELECTRIC COS. Owns: Marlboro-Hudson Gas Co., Marlboro, Mass., and Athol (Mass.) Gas & Elec. Co. | Boston 78 Devonshire | Massachusetts |
| MASSACHUSETTS GAS COS. Controls Boston Con. Gas Co., E. Boston Gas Co., Citizens Gas Lt. Co., of Quincy, Mass.; Newton & Watertown Gas Lt. Co., of Newton, Mass.; New England Coal & Coke Co., of Boston; New Eng. Fuel & Trans. Co. | Boston 111 Devonshire | Massachusetts |
| MASSACHUSETTS LIGHTING COS. Operating companies— Adams Gas Light Co., Arlington Gas Light Co., Clinton Gas Light Co., Gloucester Light Co., Leominster Gas Light Co., Lexington Gas Co., Milford Gas Light Co., Northampton Gas Light Co., North Adams Gas Light Co., Spencer Gas Co., Williamstown Gas Co., Worcester County Gas Co. Gas & Electric Improvement Co., Boston; The Light, Heat & Power Corporation, Boston; Daytona (Fla.) Public Service Co. and New Smyrna (Fla.) Public Service Co. | Boston 77 Franklin St. | Massachusetts |
| STONE & WEBSTER (Branches New York and Chicago) Operates: Blackstone Valley Gas & Elec. Co., Fall River (Mass.) Gas Works, Haverhill (Mass.) Gas Lt. Co., Paducah (Ky.) Light & Pr. Co., Puget Sound Traction, Lt. & Pr. Co. of Bellingham, Wash.; Keokuk (Ia.) Electric Co., Conn. Power Co., New London, Conn., Baton Rouge (La.) Electric Co.; Carson City (Nev.) Coal Gas Co.; Columbus (Ga.) Gas Light Co.; Pawtucket (R. I.) Gas Co.; Reno (Nev.) Pr., Lt. & Wtr. Co. | Boston 147 Milk St. | Massachusetts |
| CHARLES H. TENNEY & CO. Represents: Suburban Gas & Elec. Co., Revere, Mass.; Peoples Gas & Elec. Co., Oswego, N. Y.; Springfield (Mass.) Gas Lt. Co., Nyack, N. Y.; Malden & Melrose (Mass.) Gas Lt. Co.; Fitchburg (Mass.) Gas & Elec. Lt. Co.; No. Boston Lighting Properties; Bristol & Plainville Tramway Co., Bristol, Conn., Montpelier & Barre Lt. & Pr. Co., Montpelier, Vt. | Boston 201 Devonshire | Massachusetts |
| W. E. MOSS & CO. Operates: Coldwater (Mich.) Gas, Lt. & Fuel Co.; Columbus (Ind.) Gas Lt. Co.; Fulton (N. Y.) Fuel & Lt. Co.; Grand Haven (Mich.) Gas Co.; Citizens Gas Co. of Hannibal, Mo.; Winston-Salem (N. C.) Gas Co.; Monroe (Mich.) Gas, Light & Fuel Co.; Hillsdale (Mich.) Gas Light Co. | Detroit 710 Union Trust Bldg. | Michigan |
| AMERICAN PUBLIC UTILITIES CO. (Kelsey-Brewer interests.) Holland (Mich.) City Gas Co., Albion (Mich.) Gas Light Co., Valparaiso (Ind.) Lighting Co., Elkhart (Ind.) Gas & Fuel Co., Jackson (Miss.) Light & Traction Co., Utah Gas & Coke Co., | Grand Rapids G. Rapids Savgs. Bldg. | Michigan |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Salt Lake; Wisconsin-Minnesota Light & Power Co., serving Eau Claire, La-Crosse, Chippewa Falls, and Menominee, Wis., Red Wing and Winona, Minn.; Eastern Wis. Elec. Co., Fond du Lac, and upwards of 20 smaller communities in immediate vicinity. All operated by Kelsey-Brewer & Co., and all except Fond du Lac (which belongs to Kelsey-Brewer Co.) owned by Amer. Pub. Util. Co. | | |
| HOWE, SNOW, CORRIGAN & BERTLES.. Control Emporia (Kans.) Gas Co., McAlester (Okla.) Gas & Coke Co.; Choctaw Natural Gas Co., Okla. | Grand Rapids | Michigan |
| UNITED LIGHT AND RAILWAYS CO..... (Financial offices: 72 W. Adams, Chi. Operating hdqrs.: Grand Rapids and Davenport, Iowa.) Operates: Chattanooga (Tenn.) Gas Co.; Cedar Rapids (Ia.) Gas Co.; Muscatine (Ia.) Ltg. Co.; Ft. Dodge (Ia.) Gas & Elec. Co.; Iowa City (Ia.) Lt. & Pr. Co.; Peoples Gas & Elec. Co., Mason City, Ia.; La Porte (Ind.) Gas & E. Co.; Cadillac (Mich.) Gas Lt. Co., Ottumwa (Ia.) Gas Co.; also The Peoples Power Co. of Moline and Rock Island, Ill., The Peoples Lt. Co. of Davenport, Ia., and the Davenport (Ia.) Gas & Elec. Co. | Grand Rapids Michigan Trust Bldg. | Michigan |
| MICHIGAN LIGHT CO.................. Owns gas and electric plants at Jackson, Flint, Bay City, Kalamazoo, Saginaw, Pontiac and Manistee. | Jackson | Michigan |
| APPLEBY & WAGNER.................. Own: Consumers' Gas Co., Waycross, Ga., Gratiot County Gas Co., Alma, Mich., Washington County Gas Co., Johnson City, Tenn. | Saginaw Forester Temple | Michigan |
| UTILITIES OPERATING CO............. Own gas plants at Allegan, Otsego, Plainwell, Sturgis and South Haven, Mich.; Auburn, Brazil, Garrett, Avilla and Kendallville, Ind.; Rochester, Minn.; Manitowoc, Wis. | Minneapolis 348 Security Bldg. | Minnesota |
| PUBLIC IMPROVEMENT CO............ Controls: Bemidji, Minn.; Montevideo, Minn., and Thief River Falls, Minn. | Kalamazoo 310 Peck Bldg. | Michigan |
| UNION PUBLIC SERVICE CO............ Operates: Baldwin (Kans.) Gas Co.; Beggs (Okla.) Gas Co.; Johnson Co. Gas Co., Merriam, Kans.; Miami Co. Gas Co., Osawatomie and Paola, Kans.; Wier (Kans.) Gas Co.; Parsons (Kans.) Gas Co.; Nowata Co., Nowata Okla.; Tri-City Gas Co., Altoona and Cherryvale, Kans. and Chelsea, Okla.; Gardner (Kans.) Gas Co.; Wellsville (Kans.) Gas Co.; Anderson Co. Lt. & Ht. Co., Colony, Kans.; Richmond (Kans.) and Princeton Gas Co.; Weston (Mo.) Gas & Lt. Co. | Kansas City 1116 Commerce Bldg. | Missouri |
| THE LIGHT & DEVELOPMENT CO. OF ST. L. .............................. Operates: Cape Girardeau (Mo.) Public | St. Louis 750 Ry. Ex. Bldg. | Missouri |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Utilities Co.; Paris (Ky.) Gas and Elec. Co.; Ft. Scott (Kas.) Gas & Elec. Co.; Mitchell (S. D.) Power Co.' Oberlin (O.) Gas & Elec. Co.; Monmouth (Ill.) Pub. Serv. Co. | | |
| THE WATTS ENGINEERING CO........ Owns Columbia (Mo.) Gas Co. | St. Louis | Missouri |
| GAS CONSTRUCTION CO................ Operate: Broken Bow (Neb.) Gas Co. | Omaha<br>48th & Leavenworth Sts. | Nebraska |
| UNION POWER & LIGHT CO............ Operates North Platte (Nebr.) Lt. & Pr. Co. and Southern Ia. Elec. Co., Osceola, Ia. | Omaha<br>424 First Natl. Bk. Bldg. | Nebraska |
| SIERRA-PACIFIC ELECTRIC CO......... (Stone & Webster management) Controls: Carson City (Nev.) Coal Gas Co. and Reno Pr., Lt. & Water Co. | Reno | Nevada |
| CUMBERLAND COUNTY GAS CO...... Operates: Millville Gas Lt. Co.; Citizens Gas Co. of Landis Tp., N. J.; Pittsgrove (N. J.) Gas Co.; Fairfield (N. J.) Gas Co.; Citizens Gas Co., Vineland, N. J.; Maurice River (N. J.) Gas Co.; The Commercial Gas Co., Port Norris, N. J.; Downe Township Gas Co., Newport, N. J., and Lawrence (Tp.) Gas Co., Cedarville, N. J., and Deerfield Gas Co., Rosenhayn, N. J. | Millville | New Jersey |
| PUBLIC SERVICE GAS CO.............. Operates: (Essex Division) Essex & Hudson Gas Co.; East Newark (N. J.) Gas Lt. Co.; Morristown (N. J.) Gas Lt. Co.; (Hudson Division Hudson Co. Gas Co.; (Passaic Division) Patterson & Passaic Gas & Elec. Co.; (Southern Division) South Jersey Gas, Elec. & Trac. Co.; Princeton Lt., Ht. & Pr. Co.; (Central Division) Somerset, Union & Middlesex Ltg. Co.; New Brunswick (N. J.) Gas Lt. Co.; Shore Ltg. Co.; (Bergen Division) Gas & Elec. Co. of Bergen Co.; Ridgewood (N. J.) Gas Co. | Newark<br>80 Park Place | New Jersey |
| FLORIDA UTILITIES CO............... Moon Clay & Kaolin Co. Owns gas companies at Palm Beach, W. Palm Beach and Ocala, Fla. | Trenton<br>715 Broad St. Bk. Bldg. | New Jersey |
| BROOKLYN UNION GAS CO.............. Owns and operates: Flatbush Gas Co., 29th ward, Brooklyn; Newton Gas Co., 2d ward, Queens' Jamaica (Long Island) Gas Co.; Woodhaven (L. I.) Gas Co.; Richmond Hill & Queens County Gas Lt. Co., 4th ward, Queens. | Brooklyn<br>176 Remsen St. | New York |
| EASTERN OIL CO...................... Operates: W. Va. Central Gas Co., Elkins, W. Va.; W. Va. & Md. Gas Co., Davis, W. Va., and Cumberland, Md.; Northern Natural Gas Co., Oakland and other Maryland towns, and Terra Alta, W. Va.; West Union (W. Va.) Gas Co.; Salem (W. Va.) Natural Gas Co.; Glenville (W. Va.) Nat. Gas Co. | Buffalo | New York |
| SOUTH SHORE NATURAL GAS & FUEL Co. .......................... Owns: Dunkirk, N. Y., and other points. | Buffalo<br>842 Marine Bk. Bldg. | New York |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| EMPIRE COKE CO. Furnishes gas for Empire Gas & Elec. Co., which does all the gas and electric business in Auburn, Weedsport, Cayuga, Seneca Falls, Waterloo, Geneva, Phelps, Palmyra, Newark, Lyons and Clyde. | Geneva 103 Castle St. | New York |
| AMERICAN LIGHT & TRACTION CO. Own practically all the capital stock of Binghamton (N. Y.) Gas Works; Consolidated Gas Co., of Long Branch, N. J., Detroit (Mich.) City Gas Co.; Grand Rapids (Mich.) Gas Light Co.; Madison (Wis.) Gas & Elec. Co.; Milwaukee (Wis.) Gas Lt. Co.; Muskegon (Mich.) Traction & Ltg. Co.; St. Joseph (Mo.) Gas Co.; St. Paul (Minn.) Gas Light Co.; San Antonio (Tex.) Pub. Serv. Co.; So. St. Paul (Minn.) G. & E. Co.; West Allis (Wis.) Gas Co.; Wuawatosa (Wis.) Gas Co. | New York 120 Broadway | New York |
| AMERICAN POWER & LIGHT CO. | New York 71 Broadway | New York |
| CONSOLIDATED GAS CO. Owns directly or indirectly a majority of the capital stock of Astoria (L. I.) Lt., Ht. & Pr. Co.; Central Union Gas Co., the Bronx, N. Y. City; N. Y. & Queens Gas Co., Flushing, N. Y.; N. Y. Mutual Gas Lt. Co., N. Y. City; Northern Union Gas Co., the Bronx, N. Y. City; Northern Westchester Lighting Co., Ossining, N. Y.; Peekskill (N. Y.) Ltg. & R. R. Co.; Standard Gas Lt. Co., N. Y. City; Westchester Ltg. Co., Mt. Vernon, N. Y.; New Amsterdam Gas Co., N. Y. City. | New York 124-130 E. 15th St. | New York |
| ASSOCIATED GAS & ELEC. CO. Controls: Homer and Cortland (N. Y.) Gas Light Co.; Norwich (N. Y.) Gas & Electric Co.; Ithaca (N. Y.) Gas & Elec. Co.; Oneonta (N. Y.) Lt. & Pr. Co.; Greenville (O.) Gas Lt. Co.; Van Wert (Ohio) Gas Light Co. and Ky. Service Co., with plants at Bowling Green, Owensboro, Frankfort, Hopkinsville, Ky., and Clarksville, Tenn. | New York 43 Exchange Place | New York |
| BROOKS & CO., P. W. As Eastern States Pub. Service Co. operates N. J. Gas & Elec. Co., Dover, N. J.; Newton (N. J.) Gas & Elec. Co.; Lambertville (N. J.) Pub. Service Co. Also owns: Port Arthur (Tex.) Gas & Pr. Co. and Utah Valley Gas & Coke Co., Provo, Utah. | New York 115 Broadway | New York |
| HENRY L. DOHERTY & CO. (Cities Service Co.) Operates: Alliance (O.) Gas & Pr. Co.; Bartlesville (Okla.) Gas & Oil Co.. Beaver Oil & Gas Co., Kingsville, Ont. Can.; Brantford (Ont.) Gas Co.; Bristol (Tenn.) Gas & Elec. Co.; Buckeye State Gas & Fuel Co., and Coshocton Gas Co. of Coshocton, O.; Carthage (Mo.) Gas Co.; City Light & Traction Co., Sedalia, Mo.; Danbury & Bethel (Conn.) Gas & Elec. Lt. Co.; Denver (Colo.) Gas & Elec. Lt. Co.; Dominion | New York 60 Wall St. | New York |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Natural Gas Co. of Hamilton, Ont., Can.; Fremont (Neb.) Gas, Elec. Lt. & Pr. Co.; Knoxville (Tenn.) Gas Co.; Lebanon (Pa.) Gas & Fuel Co.; Lincoln (Neb.) Gas & Elec. Lt. Co.; Meridian (Miss.) Lt. & Ry. Co.; Montgomery (Ala.) Lt. & Water Pr. Co.; Pueblo (Colo.) Gas & Fuel Co.; Spokane (Wash.) Gas & Fuel Co.; Trumbull Public Service Co., Warren & Niles, O.; Toledo (O.) Ry. & Lt. Co.; Webb City & Carterville Gas Co.., Webb City, Mo.; Woodstock (Can.) Gas Lt. Co.; Empire Gas & Fuel Co. of Kansas, Missouri and Oklahoma; Hattiesburg (Miss.) Traction Co.; Arkansas Valley Gas Co.; Glenwood Nat. Gas Co., Ltd. (Can.); Manufacturers Nat. Gas Co., Ltd. (Can.); Quapaw (Okla.) Gas Co.; So. Ontario (Can.) Nat. Gas Co., Ltd.; S. W. Oklahoma Gas & Fuel Co.; Washita (Okla.) Gas & Fuel Co.; Western Oklahoma Gas & Fuel Co., Duncan, Lawton and Marlow, Okla.; Niagara (N. Y.) Lt., Ht. & Pr. Co.; Wichita Natural Gas Co.; Wichita Pipeline Co.; Columbus (O.) Nat. Gas Co.; Medina (O.) Gas & Fuel Co.; Mansfield (O.) Gas Lt. Co.; Ingersoll (Can.) Gas Lt. Co.; Thorold (Can.) Nat. Gas Co.; United Gas Co. (Can.); Salina (Kans.) Lt., Pr. & Gas Co.; Western Distributing Co. (Okla.); Reserve Gas Co. (Okla.); Toledo (O.) Rys. & Lt. Co.; Venture Gas Co., Morral, O.; Frost Gas Co., owning Brocton (N. Y.) Gas & Fuel Co.; Silver Creek (N. Y.) Gas & Impvt. Co., and So. Shore Nat. Gas & Fuel Co., Westfield, N. Y. | | |
| ELECTRIC BOND & SHARE CO......... Fiscal Agents: Carolina Power & Lt. Co.; Raleigh & Durham, N. C., operating Asheville (N. C.) Pr. & Lt. Co.; Yadkin River Pr. Co.; Utah Securities Co., controlling Utah Pr. & Lt. Co., which controls Utah Lt. & Tr. Co. at Ogden, Salt Lake City, etc., Utah; American Pwr. & Lt. Co., operating Portland (Ore.) Gas & Coke Co.; Kansas Gas & Elec. Co. of Wichita, Kans., Nebr. Pr. Co., Omaha; Pacific Pr. & Lt. Co. of Vancouver, Yakima and Walla Walla, Wash.; Pendleton and Astoria, Ore., and Lewiston, Idaho; Texas Pr. & Lt. Co. of Brownwood, Denison, Cleburne, Paris and Waco, Texas; Galveston (Tex.) Gas Co.; El Paso (Tex.) Gas Co.; Hutchinson (Kans.) Gas & Fuel Co.; Newton (Kans.) Gas & Fuel Co.; National Securities Corp., controlling Idaho Pr. Co. | New York 71 Broadway | New York |
| FEDERAL LIGHT & TRACTION CO...... Operates. Albuquerque (N. M.) Gas & Electric Co.; Consumers' Gas Co., Hot Springs, Ark.; Tucson (Ariz.) Gas. Elec. Lt. & Pr. Co.; Springfield (Mo.) Gas & Elec. Co.; Trinidad (Colo.) Elec. | New York 60 Broadway | New York |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Trans. Ry. & Gas Co.; Gray's Harbor Ry. & Light Co., of Aberdeen, Wash.; and various electric and railway companies. | | |
| GENERAL GAS & ELECTRIC CO. Controls: Rutland (Vt.) Ry., Lt. & Pr. Co.; Sandusky (O.) Gas & Elec. Co.; Interurban Gas Co., Easton, Penn. | New York 50 Pine St. | New York |
| COMMONWEALTH PR. RY. & LT. CO. Controls: Michigan Light Co. in Bay City, Flint, Jackson, Kalamazoo, Manistee, Pontiac and Saginaw, Mich.: Springfield, Ill., Gas & Elec. Co.; Evansville (Ind.) Public Utilities Co.; Central Illinois Light Co., Peoria and Pekin, Ill. | New York 14 Wall St. | New York |
| GENERAL ENGINEERING & MANAGEMENT CORP. Controls: Peoples Gas & Electric Co., Chillicothe, Mo.; Trenton (Mo.) Gas & Elec. Co. | New York 141 Broadway | New York |
| NASSAU & SUFFOLK LIGHTING CO. Operates: Nassau & Suffolk Lighting Co.'s plants at Garden City, Hempstead, Freeport, Merrick, Mineola, Roosevelt and other Long Island points. | New York 149 Broadway | New York |
| NATIONAL FUEL GAS CO. Controls: United Natural Gas Co., Oil City, Pa.; Iroquois Natural Gas Co., Buffalo, N. Y.; Provincial Natural Gas Co. of Ontario, Niagara Falls, Ont., Can.; Pennsylvania Gas Co., Warren, Pa.; Clarion Gas Co., Oil City, Pa. | New York 26 Broadway | New York |
| NATIONAL LIGHT, HEAT & POWER CO. Operates: Twin State Gas & Elec. Co. of Dover, N. H., Bennington and Brattleboro, Vt. | New York 111 Broadway | New York |
| NATIONAL UTILITIES CO. Operates: Ft. Scott & Nevada (Mo.) Lt., Ht., Wtr. & Pr. Co.; N. J. Gas & Elec. Co., Dover, N. J.; Port Arthur (Tex.) Gas & Pr. Co.; Hillsboro (O.) Lt. & Fuel Co. | New York 61 Broadway | New York |
| THE NORTH AMERICAN CO. Operates: St. Louis Co. Gas Co., Webster Groves, Mo.; Wisconsin Edison Co., operating Wisconsin Gas Electric Co. of Racine, Kenosha, Watertown and Burlington, Wis.; North Milwaukee Lt. & Pr. Co.; Wells Pr. Co.; Mil. Elec. Ry. & Lt. Co.; Mil. Lt., Ht. & Tr. Co...... | New York 30 Broad St. | New York |
| PEARSON ENGINEERING CORP'N. Operates gas plant at Rio de Janeiro, Brazil. | New York 115 Broadway | New York |
| THE UNITED GAS & ELECTRIC ENGINEERING CORPORATION. Controls: Altoona (Pa.) Gas Light & Fuel Co.; Citizens Gas & Fuel Co., Terre Haute, Ind.; Colorado Springs (Colo.) Lt., Ht. & Pr. Co.; Consumers Electric Light & Pr. Co., New Orleans; Elmira (N. Y.) Water, Lt. & Rd. Co.; Harrisburg (Pa.) Lt. & Pr. Co.; Houston (Tex.) Gas & Fuel Co.; Lockport (N. Y.) Lt., Ht. & Pr. Co.; Richmond (Ind.) Lt., Ht. & Pr. Co.; Union Gas & | New York 61 Broadway | New York |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Electric Co., Bloomington, Ill.; Wilkes Barre (Pa.) Co.; Birmingham (Ala.) Ry., Lt. & Pr. Co.; Houston (Tex.) Lt. & Pr. Co.; New Orleans (La.) Gas Light Co.; Lancaster (Pa.) Gas Lt. & Fuel Co.; Columbia Gas Co., Lancaster, Pa.; Leavenworth (Kans.) Lt., Ht. & Pr. Co. | | |
| H. D. WALBRIDGE & CO. Controls: Dallas (Tex.) Gas Co.; County Gas Co., Dallas, Tex.; Johnstown (Pa.) Fuel Supply Co., Penn. Pub. Serv. Co., Clearfield, Pa. | New York 14 Wall St. | New York |
| THE J. G. WHITE MANAGEMENT CORP'N. Operates the Associated Gas & Electric Co., controlling Greenville (O.) Gas Lt. Co.; Homer & Cortland Gas Lt. Co., Cortland, N. Y.; Ithaca (N. Y.) G. & E. Co.; Norwich (N. Y.) Gas & Elec. Co.; Oneonta (N. Y.) Lt. & Pr. Co.; Van Wert (O.) Gas Lt. Co.; also operates the Kentucky Public Service Co., operating in Bowling Green, Frankfort, Hopkinsville and Owensboro, Ky., and Clarksville, Tenn.; Eastern Pa. Lt., Ht. & Pr. Co., Pottsville, Pa.; Helena (Mont.) Lt. & Ry. Co., Thornapple Gas & Elec. Co., Hastings, Mich.; Palatka (Fla.) Pub. Serv. Co.; Sanford (Fla.) Public Service Co. | New York 43 Exchange Place | New York |
| ALLEN & PECK. Control Newport News and Hampton (Va.) Ry., Gas & Elec. Co. | Syracuse Vinney Bldg. | New York |
| UTICA GAS & ELEC. O. Operates the Utica plant; Central N. Y. Pr. Co., Canastota; Utica G. & E. Co., Little Falls; Utica G. & E. Co., Herkimer; Utica G. & E. Co., Ilion, N. Y.; Glens Falls (N. C.) Gas & Elec. Co.; Whitehall (N. Y.) Con. Lt. & Pr. Co.; Sandy Hill & Ft. Edward (N. Y.) United Gas, Elec. Lt., Ht. & Fuel Co. | Utica | New York |
| NORTH CAROLINA PUBLIC SERVICE CO. Operates: No. Car. Pub. Ser. Co., Greensboro, Concord, High Point, Salisbury and Spencer. | Greensboro | North Carolina |
| CAROLINA POWER & LIGHT CO. Owns Carolina Pr. & Lt. Co., Durham, N. C., and Raleigh, N. C. | Raleigh | North Carolina |
| CONTINENTAL GAS AND ELECTRIC CORP'N Operates: Gage Co. Gas. Lt. & Pr. Co., Beatrice, Neb.; Peoples Gas Co., Shenandoah, Ia.; Nebraska Ltg. Co., Plattsmouth, Neb.; Red Oak (Ia.) Gas Co.; York (Neb.) Gas Co.; Brandon (Man., Can.) Gas & Pr. Co.; Nebraska Gas & Elec. Co. and Iowa Gas & Elec. Co., both of Omaha. | Cleveland Cuyahoga Bldg. | Ohio |
| CONSOLIDATED GAS, ELEC. & WATER CO. Operates: Menominie (Wis.) Gas. Co., Hurley (Wis.) Gas Co., Ironwood (Mich.) Gas Co., Iron Mountain (Mich.) Gas Co. | Cleveland 1123 Illuminating Bldg. | Ohio |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| OHIO CITIES CO. Owns Columbus (O.) Gas & Fuel Co.; Dayton (O.) Gas Co. and Springfield (O.) Gas Co. | Columbus | Ohio |
| OHIO FUEL SUPPLY CO. (See Pittsburgh). | Columbus | Ohio |
| OHIO GAS LIGHT & COKE CO. Operates. Plants at Napoleon, Wauseon, Bryan, Stryker, Archbold, Montpelier and Delta, Ohio; Central States Gas Co., Vincennes, Ind. (operates at Vincennes and supplies Lawrenceville, Bridgeport, Sumner and Olney); Illinois Gas Co., Lawrenceville, Ill. (operates at Lawrenceville, Bridgeport, Sumner and Olney; Wabash Gas Co., Robinson, Ill. (operates at Robinson). | Napoleon | Ohio |
| EMPIRE GAS & FUEL CO. Owns, either directly or through ownership of securities, leases in Kansas and Oklahoma. | Bartlesville | Oklahoma |
| PACIFIC POWER & LIGHT CO. (See Elec. Bond & Share Co., N. Y.) Gas plants at Walla Walla, Yakima and Vancouver, Wash.; Astoria and Pendleton, Ore., and Lewiston, Idaho. | Portland Gasco Bldg. | Oregon |
| THE AMERICAN GAS CO. Owns: Bangor (Me.) Gas Lt. Co.; Burlington (Ct.) Lt. & Pr. Co.; Consolidated Lt. & Pr. Co. of Kewanee, Edwardsville, Sheffield and Galva, Ill.; Kingston (N. Y.) Gas & Elec. Co.; Luzerne Co. Gas & Elec. Co. of Kingston, Nanticoke, Hazelton, Plymouth and Fort, Pa.; Phila. Suburban Gas & Elec. Co. of Chester, Coatesville, Pottstown, Wyncote, West Chester, Phoenixville, Royersford, Spring City and other Pa. points; Petersburg (Va.) Gas Co.; Portage (Wis.) American Gas Co.; Rockford (Ill.) Gas Lt. & Coke Co.; St. Clair Co. Gas & Elec. Co. of Bellville (also operating E. St. Louis (Ill.); Waukesha (Wis.) Gas & Elec. Co.; Waterloo (Ia.) Citizens Gas & Elec. Co. | Philadelphia W. Washington Sq. | Pennsylvania |
| EASTERN LIGHT & FUEL CO. Operates: New Jersey Gas Co., Glassboro, N. J.; Schuylkill Haven (Pa.) Gas & Water Co.; Wildwood (N. J.) Gas Co.; Pottsville (Pa.) Gas Co. | Philadelphia Real Estate Trust Bldg. | Pennsylvania |
| DAY & ZIMMERMANN. Operate gas plants of the Penn. Central Light & Power Co. at Huntingdon, Lewistown; Eastern Shore Gas & Elec. Co., controlling the Cambridge (Md.) Gas, Elec. Lt. & Pr. Co. | Philadelphia | Pennsylvania |
| THE C. H. GEIST CO. Operates: Freeport (Ill.) Gas Co.; Roanoke (Va.) Gas Lt. Co.; Atlantic City (N. J.) Gas Co.; Lansing (Mich.) Fuel & Gas Co., East Chicago (Ind.) & Indiana Harbor Water Co.; Northern Alabama Gas Co., of Florence, Ala.; Wilmington (Del.) Gas Co.; Indianapolis (Ind.) Water Co. | Philadelphia Land Title Bldg. | Pennsylvania |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| GIRARDVILLE GAS CO. Operate: Girardville, Lansford and Frackville. | Philadelphia, 4014 Chestnut St. | Pennsylvania |
| GRIBBEL SYNDICATE CO. Operates: Athens (Ga.) Gas Lt. & Fuel Co.; Helena (Ark.) Gas & Elec. Co.; Tampa (Fla.) Gas Co. | Philadelphia, 1513 Race St. | Pennsylvania |
| INTERNATIONAL GAS & ELECTRIC CO. Operates: Concord (N. C.) Gas Co. and the Georgetown (S. C.) Gas & Elec. Co.; Syracuse (N. Y.) Suburban Gas Co.; Gaston Co. Gas Co., Gastonia, N. C.; Chester City Gas Co., Chester, S. C. | Philadelphia, Widener Bldg. | Pennsylvania |
| NATIONAL GAS, ELEC. LT. & PR. CO. Operates: Cape May (N. J.) Lt. & Pr. Co.; Carbondale (Pa.) Gas Co.; Goshen (Ind.) Gas Co.; Joplin (Mo.) Gas Co.; Niles (Mich.) Gas Lt. Co.; Port Huron (Mich.) G. & E. Co.; Portsmouth (O.) Gas Co.; Quincy (Ill.) Gas, Elec. Lt. & Pr. Co.; Warsaw (Ind.) Gas Co. | Philadelphia, Witherspoon Bldg. | Pennsylvania |
| INTERURBAN GAS IMPROVEMENT CO. | Philadelphia, Real Estate Trust Bldg. | Pennsylvania |
| PUBLIC SERVICE CO. Operates: Bucks Co. Public Service Co., Newtown, Pa.; Doylestown (Pa.) Gas Co.; Southern Gas Improvement Co. of Elizabeth City, Henderson and Oxford, N. C.; Rock Hill (S. C.) Gas Co. | Philadelphia, Real Estate Trust Bldg. | Pennsylvania |
| PHILADELPHIA SUBURBAN GAS & ELEC. CO. A consolidation of: Suburban Gas Co. of Philadelphia; Peoples Gas Co. of Pottstown; Coatesville Gas Co., Jenkintown and Cheltenham Gas Co.; Huntingdon Valley Light & Power Co., and Pottstown Light, Heat & Power Co., and others. | Philadelphia, S. W. Corner 7th and Locust Sts. | Pennsylvania |
| J. C. REED & CO. Control: Key West (Fla.) Gas Co.; Colon (Republic of Panama) Gas Co.; Panama (Republic of Panama) Gas Co. | Philadelphia, Morris Bldg. | Pennsylvania |
| UNION RAILWAY SUPPLY CO. Operates: Lewisburg (Pa.) Gas Co.; Ocean Co. Gas Co., Toms River, N. J.; Standard Gas Co. of Atlantic Highlands, Keansburg and Keyport, N. J.; Tuckerton (N. J.) Gas Co.; Equitable Lt., Ht. & Pr. Co., Monmouth Shore Gas Co. | Philadelphia, Real Estate Trust Bldg. | Pennsylvania |
| UNITED GAS IMPROVEMENT CO. Philadelphia Gas Works. Interested in Allentown-Bethlehem (Pa.) Gas Co.; Burlington (Ia.) Gas Lt. Co.; Charleston (S. C.) Con. Ry. & Ltg. Co.; Chester Co. Gas Co., W. Chester, Pa.; Concord (N. H.) Lt. & Pr. Co.; Consumers Gas Co., Reading, Pa.; Counties Gas & Elec. Co., Philadelphia (operating at Ardmore, Conshohocken, Norristown); Des Moines (Ia.) Gas Co.; Fulton Co. Gas & Elec. Co., Gloversville, N. Y.; Harrisburg (Pa.) Gas Co.; Kansas City (Mo.) Gas Co.; Nashville (Tenn.) Gas & Heating Co.; New Gas | Philadelphia, Broad & Arch Sts. | Pennsylvania |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Continued

| Company | City | State |
|---|---|---|
| Lt. Co., Janesville, Wis.; Northern Indiana Gas & Elec. Co.; Hammond, Ind.; (also operates Michigan City, South Bend and Ft. Wayne, Ind.; Northern Liberties Gas Co., Philadelphia; Omaha (Neb.) Gas Co.; Pensacola (Fla.) Gas Co.; Peoples Gas Lt. Co.; Manchester, N. H.; St. Augustine (Fla.) Gas & Elec. Lt. Co.; Savannah (Ga.) Gas Co.; Sioux City (Ia.) Gas & Elec. Co.; Sioux Falls (S. D.) Gas Co.; Syracuse (N. Y.) Ltg. Co.; Vicksburg (Miss.) Gas Wks.; Wyandotte Co. Gas Co., Kansas City, Kan.; Northern Indiana Gas & Elec. Co., Hammond (see above). | | |
| ARKANSAS NATURAL GAS CO.......... Pipes natural gas to Little Rock and many towns and cities in Arkansas. | Pittsburgh 223 Fourth Ave. | Pennsylvania |
| MANUFACTURERS LIGHT & HEAT CO.. Owns and controls: New Cumberland Water & Gas Co.; Venture Oil Co. and Sewickley Gas Co. | Pittsburgh 248 Fourth Ave. | Pennsylvania |
| OHIO FUEL SUPPLY CO................ Owns Northwestern Ohio Natural Gas Co., Toledo, Ohio; Point Pleasant (W. Va.) Natural Gas Co.; Miami Valley Gas & Fuel Co. Serves: Piqua, Troy, Sidney, Covington, Tippecanoe City, Mt. Sterling, South Charleston, Tarlton, Williamsport, Urbana, Rockbridge, Bloomingburg, Sedalia, Fremont City, North Hampton, New Carlisle, Lawrenceville, Beatty Town, Five Points, Lancaster, Middletown, Mt. Vernon, Xenia, Zanesville and 118 other Ohio towns. | Pittsburgh | Pennsylvania |
| THE PHILADELPHIA CO................ Controls Chartiers Valley Gas Co.; Mansfield & Chartiers Gas Co.; Penna. Nat. Gas Co., Philadelphia Co. of W. Va.; Union Gas Co. of McKeesport; Allegheny Heating Co., Pittsburgh; Equitable Gas Co., Pittsburgh; Pittsburg & W. Va. Gas Co. | Pittsburgh 435 Sixth Ave. | Pennsylvania |
| UNION NATURAL GAS CORP'N......... Controls. Logan Natural Gas & Fuel Co. of Lancaster, O.; Newark (O.) Natural Gas & Fuel Co.; Athens (O.) Gas Lt. & Elec. Co.; Buckeye Gas Co., of Circleville, O.; Bellevue (O.) Gas Co.; Marion (O.) Gas Co.; Fremont (O.) Gas, Elec. Lt. & Pr. Co.; Citizens Gas Lt. & Coke Co., Findlay, O.; Citizens Gas & Elec. Co. of Elyria and Lorain; Manufacturers Gas Co., Bradford, Pa.; Warren & Chautauqua Gas Co., of Warren, Pa. | Pittsburgh Union Bank Bldg. | Pennsylvania |
| WABASH GAS CO........................ Serves: Marshall, Martinsville, Annapolis, Hutsonville and Porterville, Ill. | Pittsburgh Benedum-Trees Bldg. | Pennsylvania |
| UNITED SERVICE CO.................. Operates: Ohio Service Co., Coshocton, Cambridge, Dennison, New Philadelphia; Warren (Pa.) Lt. & Pr. Co., Punxsutawney, Pa.; Wabash (Ind.) Water & Light Co.; E. Penna. Gas & Elec. Co., Bristol, Pa.; Hanover (Pa.) | Scranton 700 Scranton Life Bldg. | Pennsylvania |

## AMERICAN GAS SYNDICATES AND THEIR HOLDINGS —Concluded

| Company | City | State |
|---|---|---|
| Lt., Ht. & Pr. Co.; Susquehanna (Pa.) Lt. & Pr. Co. | | |
| NORTHERN CENTRAL GAS CO. Controls: Hagerstown (Md.) Lt. & Ht. Co.; Northern Central Gas Co. of Milton, Watsontown, Dewart, Montgomery and Williamsport, Pa. | Williamsport | Pennsylvania |
| BLACKSTONE VALLEY GAS & ELEC. CO. Controls: Pawtucket (R. I.) Elec. Co.; Pawtucket (R. I.) Gas Co.; Woonsocket (R. I.) Gas Co. | Pawtucket | Rhode Island |
| TEXAS POWER & LIGHT CO. Operates gas plants at Brownwood, Clebourne, Paris, Denison and Waco, the two latter natural gas. | Dallas 1322 Commerce St. (N. Y. Office, 71 Broadway | Texas |
| TWIN STATE GAS & ELEC. CO. Operates: Bennington Gas Lt. Co.; Brattleboro Gas Lt. Co.; Hoosick Falls Illuminating Co.; Dover Gas Light Co.; United Gas & Elec. Co. | Brattleboro | Vermont |
| SOUTHERN GAS & ELECTRIC CORP'N. Operates: Suffolk (Va.) Gas-Elec. Co.; Bluefield (W. Va.) Gas & Pr. Co.; Sumter (S. C.) Gas & Pr. Co., Henrico Co. Gas Co., Richmond, Va.; Gas Light Co. of Augusta, Ga. | Richmond | Virginia |
| VIRGINIA RY. & PR. CO. Owns City Gas Co., Norfolk, Va. | Richmond | Virginia |
| NORTH PACIFIC PUBLIC SERVICE CO. Operates: Gray's Harbor Gas Co., Aberdeen, Wash.; Centralia and Chehalis Gas Co., Centralia, Wash.; Bremerton-Charleston Lt. & Fuel Co. | Tacoma 323 Tacoma Bldg. | Washington |
| BOYD E. HORNER SYNDICATE | Clarksburg | West Virginia |
| COLUMBIA GAS & ELECTRIC CO. Controls: Union Gas & Elec. Co., Cincinnati; Union Lt., Ht. & Pr. Co., Covington, Ky. | Huntington | West Virginia |
| WISCONSIN SECURITIES CO. Controls: Wis. Pub. Service Co. of Green Bay, De Pere and Two Rivers; Sheboygan Gas Light Co.; Wis. Ry., Lt. & Pr., La Crosse and Winona; Manitowoc & Northern Traction Co.; West Side Pr. Co. Manitowoc; Calumet Service Co., Chilton. | Milwaukee First Nat. Bank Bldg. | Wisconsin |
| COLUMBUS GAS CONSTRUCTION CO. Owns or controls: Little Falls-Darling Gas Co., Little Falls, Minn.; Taylor (Tex.) Gas Co.; Victoria (Tex.) Gas Co.; Oconomowoc (Wis.) Gas Co. | Milwaukee Majestic Bldg. | Wisconsin |
| DOMINION GAS CO. Owns: Dominion Natural Gas Co., Ltd., of Ontario, Canada; Brantford Gas Co.; Woodstock Gas Light Co., Ltd.; Beaver Oil & Gas Co.; Ingersoll Gas Co.; Thorold Nat. Gas Co.; United Gas Co. Supplies: Natural gas from its own wells to Dunnville, Brantford, Galt, Tillsonburg, Simcoe, Paris, St. George, Dundas, Bartonville, Jarvis, Cayuga and several other smaller towns. | Hamilton | Ontario, Canada |
| QUEBEC RY., LT., HT. & PR. CO. Operates: Quebec Ry., Lt. & Pr. Co.; Quebec Gas Co.; Frontenac Gas Co. | Quebec | Canada |

# By-Product Coke Plants in United States

| Owner or Operator | Location | No. of Ovens |
|---|---|---|
| Calhoun Gas Co | Battle Creek, Mich | 18 |
| Ford Motor Co | Detroit, Mich | 120 |
| Semet-Solvay Co | Detroit, Mich | 215 |
| Michigan Light Co | Flint, Mich | 48 |
| Michigan Light Co | Kalamazoo, Mich. | |
| Michigan Alkali Co | Wyandotte, Mich | 30 |
| Minnesota Steel Co | Duluth, Minn | 90 |
| Zenith Furnace Co | Duluth, Minn | 65 |
| Minn. By-Products Coke | St. Paul, Minn | 65 |
| Laclede Gas Light Co | St. Louis Mo | 56 |
| Camden Coke Co | Camden N. J | 150 |
| Seaboard By-Prod. Coke Co | Jersey City N. J | 55 |
| Seaboard By-Prod. Coke Co | Jersey City, N. J | 110 |
| Semet-Solvay Co | Buffalo, N. Y | 60 |
| Empire Coke Co | Geneva, N. Y | 46 |
| Solvay Process Co | Syracuse, N. Y | 40 |
| Dominion Iron & Steel Co | Sydney, N. S | 120 |
| Dominion Iron & Steel Co | Sydney, N. S | 520 |
| Nova Scotia Steel & Coal Co | Sydney Mines | 1[illegible] |
| Dover By-Prod. Coke Co | Canal Dover, Ohio | 2[illegible] |
| United Furnace Co | Canton, Ohio | 4[illegible] |
| Cleveland Furnace Co | Cleveland, Ohio | |
| River Furnace Co | Cleveland, Ohio | |
| American Steel & Wire Co | Cleveland, Ohio | |
| Hamilton Otto Coke Co | Hamilton, Ohio | [illegible] |
| Ironton Solvay Coke Co | Ironton, Ohio | |
| National Tube Co | Lorain, Ohio | |
| Portsmouth Solvay Coke Co | Portsmouth, Ohio | [illegible] |
| Toledo Furnace Co | Toledo, Ohio | |
| Brier Hill Steel Co | Youngstown, Ohio | |
| Republic Iron & Steel Co | Youngstown, Ohio | [illegible]14[illegible] |
| Youngstown Sheet & Tube Co | Youngstown, Ohio | [illegible]04 |
| Youngstown Sheet & Tube Co | Youngstown, Ohio | 102 |
| Steel Co. of Canada | Hamilton, Ont | 60 |
| Algoma Steel Co | Sault Ste. Marie, Ont | 50 |
| Algoma Steel Co | Sault Ste. Marie, Ont | 110 |
| Phil. Suburb. Gas & Elec Co | Chester, Pa | 40 |
| Carnegie Steel Co | Clairton, Pa | 640 |
| Carnegie Steel Co | Clairton, Pa | 128 |
| Semet-Solvay Co. | Dunbar, Pa | 110 |
| Carnegie Steel | Farrell, Pa | 212 |
| Alleghany By-Prod. Coke Co | Glassport, Pa. | 210 |
| Jones & Laughlin Steel Co | Hazelwood, Pa | 300 |
| Cambria Steel Co | Johnstown, Pa | 147 |
| Cambria Steel Co | Johnstown, Pa | 462 |
| Bethlehem Steel Co | Lebanon, Pa | 318 |
| Bethlehem Steel Co | Steelton, Pa. | 60 |
| Bethlehem Steel Co | Steelton, Pa. | 120 |
| Lehigh Coke Co | So. Bethlehem, Pa | 424 |
| Providence Gas Co | Providence, R. I | 40 |
| Memphis Gas & Electr. Co | Memphis, Tenn | 27 |
| Seattle Lighting Co | Seattle, Wash | 20 |
| Fairmount By-Prod. Co | Fairmount, W. Va | 110 |
| LaBelle Iron Works | Follansbee, W. Va | 94 |
| National Tube Co | Benwood, W. Va | 120 |
| Northwestern Iron Co | Mayville, Wis. | 72 |
| Milwaukee Coke & Gas Co | Milwaukee, Wis. | 160 |
| Northwestern Iron Co | Mayville, Wis | 36 |
| Chattanooga Coke & Gas Co | Chattanooga, Tenn | 24 |

# and Canada (Naphtha Producers)

| Kind of oven | Coal | Coke | Ammonia as NH3 |
|---|---|---|---|
| Gas Machinery, inclined chambers | 36,000 | 25,300 | 90 |
| Semet-Solvay | 864,000 | 622,000 | 2,160 |
| Semet-Solvay | 1,343,300 | 1,009,000 | 3,696 |
| Park Gas Machinery, inclined chambers | 96,400 | 67,500 | 240 |
| Parker-Russell, Horiz. | 43,800 | 30,700 | 131 |
| Otto | 94,000 | 65,800 | 235 |
| Koppers | 600,000 | 450,000 | 1,500 |
| Otto | 200,000 | 144,000 | 500 |
| Koppers | 380,000 | 273,600 | 1,140 |
| Koppers | 320,000 | 240,000 | 880 |
| Otto | 360,000 | 252,000 | 990 |
| Koppers | 340,500 | 255,350 | 937 |
| Koppers | 681,000 | 510,700 | 1,874 |
| Semet-Solvay | 386,000 | 289,500 | 965 |
| Semet-Solvay | 146,000 | 102,200 | 401 |
| Semet-Solvay | 65,000 | 45,500 | 195 |
| Koppers | 720,000 | 518,400 | 2,160 |
| Otto | 1,664,000 | 1,198,080 | 4,576 |
| 30 Bauer, 160 Bernard | 159,000 | 110,000 | .... |
| Roberts | 120,000 | 87,600 | 300 |
| Koppers | 280,000 | 204,400 | 770 |
| emet-Solvay | 450,000 | 337,500 | 1,125 |
| ppers | 1,300,000 | 949,000 | 3,575 |
| opers | 1,150,000 | 839,500 | 3,162 |
| o | 240,000 | 168,000 | 720 |
| met-Solvay | 432,000 | 270,000 | 1,031 |
| oppers | 1,320,000 | 963,600 | 3,630 |
| S met-Solvay | 770,000 | 559,900 | 1,944 |
| Koppers | 560,000 | 408,800 | 1,540 |
| oppers | 520,000 | 397,600 | 1,438 |
| Koppers | 1,020,000 | 744,600 | 2,805 |
| Koppers | 1,300,000 | 949,000 | 3,575 |
| Koppers | 650,000 | 474,500 | 1,788 |
| Wilputte | 342,000 | 260,400 | 779 |
| Wilputte | 285,000 | 217,000 | 650 |
| Koppers | 681,000 | 510,700 | 1,874 |
| Semet-Solvay | 125,000 | 87,500 | 313 |
| Koppers | 4,000,000 | 2,800,000 | 12,000 |
| Koppers | 800,000 | 560,000 | 2,400 |
| Semet-Solvay | 248,000 | 173,600 | 682 |
| Otto | 830,000 | 581,000 | 2,283 |
| Otto | 260,000 | 195,000 | 650 |
| Koppers | 2,000,000 | 1,300,000 | 5,000 |
| Otto | 529,200 | 338,888 | 1,293 |
| 343 Otto, 92 Koppers, 27 Gas Mach. | 1,529,500 | 1,223,700 | 3,440 |
| 228 Otto, 90 Semet-Solvay | 887,000 | 638,000 | 2,267 |
| Koppers | 375,000 | 270,000 | 1,031 |
| Semet-Solvay | 516,000 | 371,500 | 1,354 |
| Koppers | 2,400,000 | 1,920,000 | 5,400 |
| Koppers | 240,000 | 172,800 | 720 |
| Gas Mach., including slots | 59,000 | 41,300 | 148 |
| National Chamber Oven | 48,600 | 29,200 | 90 |
| Koppers | ...... | ........ | .... |
| Koppers | 610,000 | 445,300 | 1,677 |
| Semet-Solvay | 270,000 | 189,000 | 743 |
| Otto | 320,000 | 230,400 | 800 |
| Semet-Solvay | 732,000 | 549,000 | 2,104 |
| Otto | 197,000 | 147,000 | .... |
| Semet-Solvay | 173,000 | 124,000 | 432 |

# The Flow of Oil in Pipes

The quantity of oil of the same viscosity as water discharged through a pipe is in accordance with the following formula:

$Q = a\,v$ in which Q is the quantity discharged in cubic feet per second
a is the pipe area in square feet
v is the velocity in feet per second

To find the velocity discharged from the pipe line, knowing the head, length and inside diameter use the following formula:

$$\frac{Q}{A} = v = m\sqrt{\frac{hD}{L + 54\,D}}$$

in which v = approximate mean velocity in feet per second
m = coefficient from table below
D = diameter of pipe in feet
h = total head in feet
L = total length of line in feet

Value of Coefficient "m"

| Diameter of Pipe Feet | Inches | m | Diameter of Pipe Feet | Inches | m |
|---|---|---|---|---|---|
| 0.1 | 1.2 | 23 | 1.5 | 18 | 53 |
| 0.2 | 2.4 | 30 | 2.0 | 24 | 57 |
| 0.3 | 3.6 | 34 | 2.5 | 30 | 60 |
| 0.4 | 4.8 | 37 | 3.0 | 36 | 62 |
| 0.5 | 6.0 | 39 | 3.5 | 42 | 64 |
| 0.6 | 7.2 | 42 | 4.0 | 48 | 66 |
| 0.7 | 8.4 | 44 | 5.0 | 60 | 68 |
| 0.8 | 9.6 | 46 | 6.0 | 72 | 70 |
| 0.9 | 10.8 | 47 | 7.0 | 84 | 72 |
| 1.0 | 12.0 | 48 | 10.0 | 120 | 77 |

The above coefficients are averages deduced from a large number of experiments. In most cases of pipes carefully laid and in fair condition they should give results within 5 to 10% of the truth.

Example: Given the head, h = 50 feet, the length, L = 5280 feet, and the diameter D = 2 feet; to find the velocity and quantity of discharge.

The value of the coefficient m from the table when D = 2 feet is m = 57.

Substituting these values in the formula, we get:

$$v = 57\left(\frac{50 \times 2}{5280 + 108}\right) = 57\left(\frac{100}{5388}\right) = 57 \times 0.136 = 7.52 \text{ ft. per second.}$$

To find the discharge in cubic feet per second, multiply this velocity by the area of cross section of the pipe in square feet.

Thus, 3.1416 x (1) 2 x 7.752 = 24.35 cubic feet per second.

Since there are 7.48 gallons in a cubic foot, the discharge in gallons per second = 24.35 x 7.48 = 182.1.

The above formula is only an approximation, since the flow is modified by bends, joints, incrustations, etc. Wrought pipes are smoother than cast iron ones, thereby presenting less friction and less encouragement for deposits; and being in longer lengths, the number of joints is reduced, thus lessening the undesirable effects of eddy currents.

# Principal Pipelines

| Pipeline | Mileage | | Capacity, barrels |
|---|---|---|---|
| Alluwe Pipeline Co. (Kas. Oil Ref. Co.) | 40 | From Alluwe Dist., Okla., to Coffeyville, Kans. | 2,500 |
| Amalgamated Petroleum Co. | 70 | From Salt Lake Dist., Cal., to Los Angeles, Cal. | 9,000 |
| American Petroleum Co. | 20 | From Humble to E. Houston, Tex. | .... |
| Associated Oil Co. | 105 | From Coalinga Dist., Cal., to Monterey, Cal. | 15,000 |
| Associated Oil Co. | 60 | From Santa Barbara Co., Cal. to Gaviota, Cal. | 23,000 |
| Arkansas City Pipeline Co. | .. | From Blackwell to Arkansas City, Kans. | .... |
| Associated Pipeline Co. | 281 | From Kern River Dist., Cal., to Port Costa, Cal. | 13,000 |
| Associated Pipeline Co. | 278 | From Kern River Dist., Cal., to Port Costa, Cal. | 26,000 |
| Bessemer Pipeline | .. | From Titusville, Pa., to W. Pa. | .... |
| Buckeye Pipeline Co., Lima Division | 700 | From Ohio-Ind. state boundary to Ohio-Penn. state boundary | 75,000 |
| Buckeye Pipeline Co., Macksburg Division | 350 | From Eastern Ohio to Ohio-Penn. and Ohio-W. Va. boundary | 10,000 |
| Colive Oil Co. | ... | From Healdton to Ardmore... | .... |
| Cosden & Co. | ... | From adjacent wells to Bigheart, Okla. | 500 |
| Cosden Pipeline Co. | ... | From various Okla. oil dist. to West Tulsa, Okla. | 30,000 |
| Crescent Pipeline Co. | 315 | From Greggs, Pa., to Marcus Hook, Pa. | 5,600 |
| Crown Pipeline Co. | 58 | From Okmulgee, Okla., to Muskogee, Okla. | .... |
| Cumberland Pipeline Co. | 475 | From Southeastern Kentucky to Kentucky-W. Va. bound. | 10,000 |
| Emery Pipeline Co. | 480 | From adjacent oil dist. to Bradford, Pa. | 1,000 |
| Empire Pipeline Co. | 85 | From Eldorado and Augusta, Kans., to Ponca City, Okla | .... |
| Empire Pipeline Co. | 67 | From Ponca City, Okla., to Norfolk, Okla. | .... |
| Empire Pipeline Co. | 70 | From northern Oklahoma to Independence, Kans. | .... |
| Empire Pipeline Co. | 55 | From Healdton, Okla., to Gainesville, Tex. (Total)... | 35,000 |
| Empire Pipeline Co. | 17 | From Gainesville, Tex., to Red River, Tex. | 8 inch |
| Eureka Pipeline Co. | 4,300 | From Kentucky-W. Va. boundary and Ohio-W. Va. boundary to W. Va.-Pa. boundary | 65,000 |
| Franklin Pipe Co. | ... | From adjacent fields to Franklin, Pa. | 150 |
| General Pipeline Co. | 156 | From Midway Dist., Cal., to Los Angeles and San Pedro | 25,000 |
| General Pipeline Co. | 52 | From Liebere, Cal., to Mojave, Cal. | 5,000 |
| Gulf Pipeline Co. | 458 | From Tex.-Okla. State Line to Port Arthur, Tex. | 28,000 |
| Gulf Pipeline Co. | 76 | From Batson, Tex., to Sour Lake and Houston | 14,000 |
| Gulf Pipeline Co. | 117 | From La.-Tex. State Line to Lufkin Station, Tex. | 9,600 |
| Gulf Pipeline Co. | 124 | From Saltillo Station, Tex., to Fort Worth, Tex. | 7,000 |
| Gulf Pipeline Co. of Okla. | 275 | From Bartlesville, Okla., to Okla.-Tex. boundary | 25,000 |

## PRINCIPAL PIPELINES—Continued

| Pipeline | Mileage | | Capacity, barrels |
|---|---|---|---|
| Gulf Refining Co. of La. | 21 | From Mansfield, La., to La.-Texas boundary | 10,000 |
| Gulf Pipeline Co. | 305 | From Olean, Tex., to Red River, Tex. | 8 inch |
| Gulf Pipeline Co. | 124 | From Fort Worth, Tex., to Saltillo, Tex. | 6 inch |
| Gulf Pipeline Co. | 98 | From Caddo, Tex., to Lufkin, Tex. | 6 inch |
| Gulf Pipeline Co. | 86 | From Ranger, Tex., to Fort Worth, Tex. | 8 inch |
| Gulf Pipeline Co. | 63 | From Houston to Sour Lake, Tex. | 6 inch |
| Hale Petroleum Co. | 20 | From Eldorado, Kan., to Wichita, Kan. | 7,500 |
| Illinois Pipeline Co. | 1,300 | From Alton, Ill., to Centerbridge, Pa. | 60,000 |
| Illinois Pipeline Co. | 25 | From Grass Creek, Wyo., to Chatham, Wyo. | .... |
| Illinois Pipeline Co. | 20 | From Elk Basin, Wyo., to Frannie, Wyo. | .... |
| Illinois Pipeline Co. | 20 | From Big Muddy, Wyo., to Casper, Wyo. | 20,000 |
| Imperial Pipeline Co., Ltd. | 155 | From Sarnia, Ont., to Cygnet, Ohio | 8 inch |
| Indiana Pipeline Co. | 800 | From Griffith, Ind., to Indiana-Ohio boundary | 110,000 |
| Magnolia Petroleum Co. | 569 | From Electra, Tex., to Sabine, Tex. | 60,000 |
| Magnolia Petroleum Co. | 137 | From Healdton, Okla., to Fort Worth, Tex. | 60,000 |
| Magnolia Petroleum Co. | 150 | From Cushing Dist., Okla., to Addington, Okla. | 50,000 |
| Magnolia Petroleum Co. (Double Line) | 800 | From Red River, Tex., to Beaumont, Tex. | 8 inch |
| Magnolia Petroleum Co. | 76 | From Electra, Tex., to Bowie, Tex. | 8 inch |
| Maryland Pipeline Co. | .. | From Kay County, Okla., to Ponca City, Okla. | .... |
| Midwest Refining Co. | 90 | From Salt Creek Dist., Wyo., to Caspar, Wyo. | 13,000 |
| National Pipeline Co. | 60 | From oil fields in Wood Co., Ohio, to Findlay, Ohio | 1,000 |
| National Pipeline Co. | 110 | From oil fields in southeastern Ohio to Marietta, Ohio | 500 |
| National Transit Co. | 205 | From Nedska, Pa., to New York-Pa. boundary | .... |
| National Transit Co. | 175 | From Colegrave, Pa., to Milway, Pa. | .... |
| National Transit Co. | 35 | From Milway, Pa. to Fawn Grove Pa. | 75,000 |
| National Transit Co. | 70 | From Milway, Pa., to Point Breeze, Pa. | .... |
| National Transit Co. | 70 | From Milway, Pa., to Centerbridge, Pa. | .... |
| Natrona Pipeline Co. | 90 | From Salt Creek, Wyo., to Casper, Wyo. | 6 inch |
| New York Transit Co. | 130 | From Pa.-New York boundary to Buffalo, N. Y. | 55,000 |
| New York Transit Co. | 1,100 | From Olean, N. Y., to Bayonne, N. J., and Long Island, N. Y. | .... |
| Northern Pipe Co. | 525 | From Pa.-Ohio boundary to Pa.-N. Y. boundary | 60,000 |
| Oklahoma Pipeline Co. | 229 | From Creek County, Okla., to McCurtain, Okla. | 35,000 |
| Paragon Refining Co. | 237 | From Sandusky County Ohio, to Toledo, Ohio | 4,000 |
| Pierce Pipeline Co. | 135 | From Healdton, Okla., to Fort Worth, Tex. | .... |

## PRINCIPAL PIPELINES—Continued

| Pipeline | Mileage | | Capacity, barrels |
|---|---|---|---|
| Prairie Pipeline Co. | ... | From Drumright, Okla., to Ranger, Tex. | 8 inch |
| Prairie Pipeline Co. (Double (Line) | 260 | From Ranger, Tex., to Red River, Tex. | 8 inch |
| Prairie Pipeline Co. | 701 | From Cushing Dist., Okla., to Humboldt, Kan. | 100,000 |
| Prairie Pipeline Co. | 1,820 | From Humboldt, Kan., to Sugar Creek, Mo., and Wood River, Ill. | 94,000 |
| Prairie Pipeline Co. | 90 | From McCurtain, Okla., to Ida, La. | 31,000 |
| Prairie Pipeline Co. | 85 | From Eldorado-Augusta Kan., to Neodesha, Kan. | .... |
| Producers' & Refiners' Pipe Line Co. | 210 | From Watertown, Ohio, to Titusville, Pa. | 9,000 |
| Producers' Transportation Co.. | 41 | From Coalinga Dist., Cal., to Junction, Cal. | 15,000 |
| Producers' Transportation Co.. | 50 | From Sunset Dist., Cal., to Junction Cal. | 20,000 |
| Producers' Transportation Co.. | 39 | From Kern River Dist., Cal., to McKittrick, Cal. | .... |
| Producers' Transportation Co.. | 13 | From Lost Hills Dist., Cal., to Trunk Line, Cal. | .... |
| Producers' Transportation Co.. | 3 | From Belridge Dist., Cal., to Trunk Line, Cal. | .... |
| Producers' Transportation Co.. | 74 | From Junction, Cal., to Port San Luis, Cal. | 30,000 |
| Pure Oil Pipeline Co. | 250 | From Morgantown, W. Va., to Marcus Hook, Pa. | 10,000 |
| Rio Brava Oil Co. | 13 | From Saratoga, Tex., to Sour Lake, Tex. | 1,500 |
| Pierce Pipeline Co. | 76 | From Fort Worth, Tex., to Red River, Tex. | 8 inch |
| Sinclair-Cudahy Pipeline Co.... | 750 | From Cushing Dist., Okla., to Kansas City and Chicago.. | .... |
| Sinclair-Cudahy Pipeline Co.... | 70 | From Cushing Dist., Okla., to Coffeyville, Kan. | .... |
| Sinclair-Cudahy Pipeline Co.... | 340 | From branches and lateral in Okla. and Kansas | 50,000 |
| Sinclair-Cudahy Pipeline Co.... | ... | From Cushing field, Okla., to Whiting, Ind. | 8 inch |
| Sinclair-Cudahy Pipeline Co.... | ... | From Cushing field to Healdton, Okla. | 8 inch |
| Southern Pipeline Co. | 1,130 | From Pa.-W. Va. boundary to Philadelphia, Pa. | 51,000 |
| Southwestern Penn. Pipelines.. | 1,650 | Operates exclusively in southwestern Pennsylvania | 45,000 |
| Standard Oil Co., Cal. | 281 | From Kern River Dist., Cal., to Richmond, Cal. | 65,000 |
| Standard Oil Co., Cal. | 32 | From Midway Dist., Cal., to Bakersfield, Cal. | 65,000 |
| Standard Oil Co., Cal. | 29 | From Coalinga Dist., Cal., to Mendota, Cal. | 28,000 |
| Standard Oil Co., Cal. | 21 | From Lost Hills Dist., Cal., to Pond, Cal. | 20,000 |
| Standard Oil Co., Cal. | 24 | From Northan Dist., Cal., to El Segundo, Cal. | 27,000 |
| Standard Oil Co., Cal. | 45 | From Newhall Dist., Cal., to Ventura, Cal. | 1,400 |
| Standard Oil Co., Cal. | 32 | From Santa Mina Dist., Cal., to Port Hartford, Cal. | 20,000 |
| Standard Oil Co. of La. | 522 | From Ida, La., to Baton Rouge, La. | 35,000 |
| Sun Co. | 250 | From Seneca and Wood Co., O., to Toledo, O. | 1,000 |
| Sun Pipeline Co. | 100 | From Humble, Tex. (also Yale, Okla.) to Sabine Pass, Tex. | 21,000 |
| Sun Pipeline Co. | 53 | From Humble, Tex., to Sour Lake, Tex. | 6 inch |

## PRINCIPAL PIPELINES—Concluded

| Pipeline | Mileage | | Capacity, barrels |
|---|---|---|---|
| Sun Pipeline Co. | 25 | From Spindle Top, Tex., to Sabine Pass, Tex. | 8 inch |
| Sun Pipeline Co. | 23 | From Sour Lake, Tex., to Spindle Top, Tex. | 8 inch |
| Sun Pipeline Co. | 16 | From Batson, Tex., to Sour Lake, Tex. | 8 inch |
| Sun Pipeline Co. | 4 | From Spindletop, Tex., to Sun Station, Tex. | 6 inch |
| Texas Co. (main lines) | 742 | From Bartlesville, Okla., to Port Arthur, Tex. | 20,000 |
| Texas Co. (main lines) | 160 | From Electra, Tex., to West Dallas, Tex. | 17,000 |
| Texas Co. (main lines) | 253 | From Vivian, La., to Port Arthur, Tex. | 20,000 |
| Texas Co. (main lines) | 96 | From Evangaline, Tex., to Garrison, Tex. | 9,600 |
| Texas Co. (main lines) | 60 | From Healdton, Okla., to Sherman, Tex. | 12,000 |
| Texas Co. (laterals) | 222 | From in Oklahoma and Texas to. | ..... |
| Texas Co. | 400 | From Dennison, Tex., to Port Arthur. | 6 inch |
| Texas Co. | 155 | From Logansport, Tex., to Port Arthur, Tex. | 8 inch |
| Texas Co. | 85 | From Ranger, Tex., to Fort Worth, Tex. | 8 inch |
| Texas Co. (two lines) | 60 | From Dallas, Tex., to Fort Worth, Tex. | 8 inch |
| Texas Co. | 25 | From Dayton, Tex., to Goose Creek. | 8 inch |
| Texas Co. | 130 | From Electra, Tex., to Fort Worth, Tex. | 6 inch |
| Texas Co. | 15 | From Humble, Tex., to Houston, Tex. | 6 inch |
| Texas Co. | ... | From Healdton, Okla., to Gates Station, Tex. | 8 inch |
| Tidewater Pipe Co. (main line) | 830 | From Stoy, Ill., to Bayonne, N. J. | 11,000 |
| Tidewater Pipe Co. (laterals) | 1,929 | In Pennsylvania, N. Y., Ill., and Ind. | ..... |
| Union Oil Co. | 65 | From Orcutt, Cal., to Port San Luis, Cal. | ..... |
| Union Oil Co. | 43 | Local lines in Ventura County, Cal. | ..... |
| Union Oil Co. | 51 | Local lines in Los Angeles, Orange County, Fields, Cal. | ..... |
| Valley Pipeline Co. | 170 | From Coalinga Dist., Cal., to San Francisco Bay | 25,000 |
| War Pipeline Co. | ... | From Cushing Field, Okla., to Humboldt, Kans. | 8 inch |
| Wilburine Pipeline Co. | 125 | From Shannopin, Pa., to Warren, Pa. | 5,000 |
| Yarhola Pipeline Co. | 135 | From Healdton, Okla., to Cushing, Okla. | 9,000 |
| Yarhola Pipeline Co. | 400 | From Cushing, Okla., to St. Louis, Mo., and Wood River, Ill. | 36,000 |

# Losses in the Storage of Crude Petroleum

The principal losses in the storage of crude petroleum are due to evaporation, to fire and to seepage.

Oils having the greatest loss are the crude oils containing the most gasoline, since they are the most volatile, most readily form explosive and inflammable mixtures and due to their low viscosity most readily flow through walls of loose texture.

The loss from evaporation is greater the larger the amount of gasoline. The loss also depends upon the temperatures of storage, upon the amount of surface exposed to the atmospheric circulation. If the tank or container is perfectly tight, then there will be no loss by evaporation.

There are three general types of storage now in use in the Mid-Continent fields, the earthen reservoir, the steel tank with wooden roof and the steel tank with a steel gas tight roof.

The 55,000 and 35,000 barrel steel tanks are the usual sizes. Altogether there are more than 3,000 of these large steel tanks in use in the Mid-Continent field.

The earthen storage is extremely wasteful from both seepage and evaporation. Petroleum standing in this type of reservoir has been known to shrink 40% in volume in two or three weeks. The shrinkage in value is of course much greater as the portion lost by evaporation is the best of the gasoline.

The following losses by evaporation took place in steel tanks with no seepage, with wooden roof covered with paper and tarred and apparently tight. The oil was of 40°Be′ gravity and the tanks were of a diameter of 114½ feet.

| Capacity | Loss in Gauge | Actual Loss | Period | Per Cent Loss |
|---|---|---|---|---|
| 55,000 bbls. | 1 ft. 1¾ in. | 2101 bbls. | 5 mos. | 4.2 |
| 55,000 bbls. | 1 ft. 2⅝ in. | 2235 bbls. | 4½ mos. | 4.6 |
| 55,000 bbls. | 11⅛ in. | 1700 bbls. | 3½ mos. | 3.4 |
| 55,000 bbls. | 1 ft. ½ in. | 1910 bbls. | 3¼ mos. | 3.8 |

The above figures indicate that there might be a loss of 1% per month of storage in wood roof steel tanks and this might amount to as much as 6,000 barrels per year per tank.

It has been claimed that oil stored in white tanks is subjected to 1 to 1½% less evaporation than in red tanks and 2½% less evaporation than in black tanks.

Various types of insulation have been used with success.

A typical storage temperature for the Mid-Continent field for oil stored above ground would be 80°F. A typical temperature of the ground for a submerged tank would be 60°F which would more nearly approach the storage temperature of the air for the whole year.

If tanks could be successfully and cheaply built in the ground, they would have the advantage of almost perfect insulation from outheat, and the oil would be stored at practically the temperature at which it comes from the ground. For this submerged type of tank, concrete construction would be proper if capable of perfect construction. It should be monolithic, well reinforced and lined with a coating impervious to water and gasoline.

Next in quantity after the evaporation losses in the storage of crude oil is the loss due to fire. Petroleum fires destroyed 12,850,000 barrels of oil in the United States in 1918. From Jan. 1, 1908, to Jan. 1, 1918, approximately 12,850,000 barrels of oil and 5,024,506,000 cubic feet of gas were destroyed by fire in the United States entailing a total estimated property loss of $25,254,000. During this period 503 fires were reported. Of these fires 310 were caused by lightning and 193 by other causes. The losses from the fires caused by lightning were estimated to be $11,148,000 and from those due to other causes, $14,106,200. Directly and indirectly the fires resulted in the deaths of nearly 150 persons and were responsible for almost as many more being permanently disabled.

Loss from fire in the oil field storage in the year 1916 amounted to about $4,000,000.

The causes of fires are electrical discharges or open flames in the presence of an inflammable or explosive mixture of gasoline and air. The amount of gasoline vapor in air necessary for an explosive mixture is within the limits of 1½% and 5% by weight. Less than the lower limit or more than the upper limit will not inflame. In an open tank if the amount at the surface of the oil exceeds 1½% there is at some point an explosive mixture and an igniting temperature of 900°F. or over will cause it to take fire. In a perfectly tight tank with gasoline vapor in excess of the upper limit for an explosive mixture, there will be no fire unless the roof of the tank is open at some point.

The ingress of a flame through an opening may be prevented in the same way that the flame in the Davy miner's lamp is prevented from passing outward. This operates by having some metal screen or other material cool the flame and prevent it being propagated into the tank. This will not prevent ignition from an electrostatic discharge in the vapor space of the tank.

Methods for prevention of fires of oil in storage are as follows:

1st. Means of preventing the passage of the spark in a portion of the unfilled face of the tank.

2d. The maintenance of a mixture in the unfilled portion of the tank which is not an explosive mixture.

3d. A tank so placed and constructed that the cooling effect of the walls will tend to smother the flames and the ingress of air will be so arranged that the fire is not readily fed.

4th. A means for quickly eradicating the fire after it is ignited.

Several more or less successful methods for extinction of oil tank fires have been in use. The best involves the use of mixtures of sodium bicarbonate and sulphuric acid which produce sufficient carbon dioxide to smother the flame. If some sort of saponifying agent is used the carbon dioxide will make a froth which will float on the surface of the oil and is very effective in extinguishing the flame.

The application of steam is very effective but in the storage of a very large amount of oil the steam is not always available when needed and at the point where needed.

For small oil fires dust or other finely divided mineral matter is effective in extinguishing the fire.

# Fuel Oil Storage Tanks Regulations Drafted by Fire Protection Association

The Committee on Inflammable Liquids of the National Fire Protection Association has submitted the following tentative regulations covering the construction of concrete tanks for fuel oil storage.

**Setting of Tanks.**—(a) Tanks, if underground, shall be buried so that the top of the tank will be not less than three feet below the level of the surface of the ground and below the level of any piping to which the tanks may be connected.

(b) Tanks shall be set on a firm foundation.

(c) All tanks shall be provided with a concrete or other noncombustible roof.

**Material and Construction of Tanks.—(a) Reinforcement.**—Sufficient steel reinforcement shall be used to resist the oil pressure, and the horizontal and vertical reinforcement shall be proportioned properly and located to reduce the shrinkage cracks, so that they will be too minute to permit leakage. The fiber stress in the steel shall not exceed 10,000 pounds per square inch. (Note. A fiber stress of 10,000 pounds per sq. in. should prevent shrinkage cracks although a number of tanks have been designed with a fiber stress of 6,000 to 8,000 pounds.)

(b) **Concrete.**—The concrete for floor and walls shall be at least 8 inches thick, mixed in the proportion of 1:2:3 or better 1:1½:3 and having the coarse aggregate of clean, dense, crushed rock or gravel ranging in size from one inch down. The concrete shall be thoroughly mixed, carefully placed and worked around the reinforcement. The forms should not be held together by wire as is frequently done in building construction because leakage is likely to take place along the wire. The concrete shall preferably be poured in a continuous operation so as to form a monolithic construction. (Note. —Where this cannot be done, the bottom shall be poured without joints and the walls as a second continuous operation. One method of making a tight joint between the bottom of the tank and the walls is by means of a strip of galvanized iron six inches wide with joints riveted and soldered, so as to form a continuous band. This strip should be vertically embedded three inches in the floor slab and on the center line of the wall. The floor slab under the walls should be thoroughly cleaned, and before pouring the walls a mixture of 1:1 mortar should be placed in the bottom of the forms and around the galvanized strip to make a tight joint.)

(c) **Finish.**—As soon as the wall and sides have been poured the floor shall be floated and troweled smooth. The wall forms shall be removed as soon as the concrete has hardened sufficiently to be self-sustaining and all projections and irregularities shall be removed from the surface and all cavities filled with a 1:1 mortar thoroughly rubbed in and troweled smooth. No plastering shall be applied.

(d) **Aging.**—The concrete shall be allowed to harden at least 30 days and longer if possible. (Note.—To assist in the setting of the concrete before it becomes oil soaked it is advantageous to use several priming coats of a 1:4 solution of 40° Baume' sodium silicate, followed by a finish coat of a 1:2 solution. This forms a glazed sur-

face on the concrete, which although it is not permanent, gives the concrete an opportunity to harden until the protection from the silicate of soda is not longer necessary.)

**Location of Pipe Connections.**—All pipe connections to the tank shall be made through the top.

**Venting of Tanks.**—(a) Tanks shall be provided with a permanently open vent, or with a combined fill and vent fitting so arranged that the fill pipe cannot be opened without opening the vent pipe.

(b) Vent openings shall be screened (30x30 brass mesh or equivalent) and shall provide sufficient area for allowing proper flow of liquid during the filling operation. Permanently open vent pipes shall be provided with weatherproof hoods and terminate at a point at least twelve feet above the top of the fill pipe and never within less than three feet, measured horizontally and vertically, from any window or other building opening. Where a battery of tanks is installed vent pipes may be run into a main header. Individual vent pipes should, however, be screened between tank and header and connection to the header should be not less than one foot above the level of the top of the highest reservoir from which the tanks may be filled.

(c) Fill pipes shall be screened and when installed in the vicinity of a building, shall not be located within five feet of any door or other opening and shall terminate in a metal box or casting provided with means for locking.

# Rules Governing the Shipment of Oil Samples by Express

Oils having a flash point of 20°F or below must not be shipped in quantities greater than one gallon.

This includes benzine, benzol, casinghead gasoline, casinghead naphtha, coal tar light oils, coal tar naphthas, distillates, petroleum ether, gas drips, gasoline, liquefied petroleum gas, naphthas, naphtha distillates, gas oil, pentane and toluol.

Not more than one gallon shall be in one outside container and the package containing the fluid must not be entirely filled.

The vacant space must be not less than 2% of the contents. If in tightly closed metal cans, the package must be packed in wooden boxes. The package shall be labeled with a red label.

Crude oils, crude petroleums or petroleum naphthas or liquids having a flash point above 20°F and below 80°F may be shipped in quantities less than six gallons in one package. The package, if a metal can, must be covered with wood or packed in wooden boxes.

Gasoline or naphtha with a flash point of 20°F or lower when shipped in glass must be in capacity of one pint or less and cushioned in fiber board or corrugated straw board containers and with not more than eight quarts in one package.

Lubricating oils, motor oils, coal oil, fuel oil, illuminating oil, kerosene and other petroleum oils with a flash point higher than 80°F are not subject to special rules governing the transportation of dangerous articles by express and do not require special labels. The red label is required on all inflammable liquids, including light crude oils and light distillates having a flash point below 80°F.

# Ownership of Tank Cars

## TANK CARS OWNED BY RAILROADS.

| Name and Location. | Tank Cars. |
|---|---|
| Colorado & Southern | 14 |
| Delaware River & Union R. R. | 211 |
| Denver & Rio Grande | 44 |
| East Jersey R. R. | 120 |
| El Paso & Western | 98 |
| Kansas City Southern Ry. Co. | 193 |
| Los Angeles & Salt Lake R. R. Co. | 214 |
| Midland Valley R. R. Co. | 97 |
| Missouri, Kansas & Texas Ry. | 677 |
| Morenci Southern Ry. Co. | 2 |
| New Orleans, Texas & Mexico R. R. | 75 |
| Northwestern Pacific R. R. Co. | 34 |
| Oregon-Washington R. R. & Nav. Co. | 44 |
| Pacific Electric Ry. Co. | 29 |
| Pennsylvania R. R. Co. | 514 |
| Philadelphia & Reading Ry. Co. | 20 |
| St. Louis & San Francisco R. R. Co. | 629 |
| St. Louis, Brownsville & Mexico Ry. | 59 |
| St. Louis, Southwestern Ry. Co. | 29 |
| San Antonio & Aransas Pass Ry. Co. | 81 |
| Santa Fe Ry. Co. | 3,178 |
| Santa Fe & Arizona Ry. | 4 |
| Southern Pacific Ry. | 2,963 |
| Texas & New Orleans R. R. Co. | 459 |
| Trinity & Brazos Valley R. R. | 25 |
| | 9,813 |

## TANK CARS OWNED BY OIL INDUSTRY.

| Name and Location. | Tank Cars. |
|---|---|
| Akin Gasoline Co., Tulsa, Okla. | 3 |
| Ajax Gasoline Co., Kansas City | 4 |
| American Oil Products Corp., Erie | 3 |
| American Oil Works, Titusville, Penn. | 57 |
| American Refining Co., Tulsa | 256 |
| Anderson & Gustafson, Cushing, Okla. | 59 |
| Asphaltum Oil & Refining Co., Los Angeles | 3 |
| Associated Oil Co., California | 337 |
| Atlantic Refining Co., Philadelphia | 4 |
| Atwood Refining Co., Oklahoma City | 23 |
| Allied Refining Co., Okmulgee | 63 |
| Barkhausen Oil Co., Green Bay, Wis. | 1 |
| Beaver Refining Co., Washington, Pa. | 13 |
| J. B. Berry Sons Co., Oil City, Pa. | 105 |
| Bigheart Petroleum Refining Co., Bigheart, Okla. | 25 |
| F. W. Bird & Sons, E. Walpole, Mass. | 3 |
| Blake Oil Co., Liberal, Kansas | 1 |
| Bliss Refining Co., Augusta, Kansas | 37 |
| Boynton Gasoline Co., Tulsa | 4 |
| Brooks Oil Co., Cleveland, Ohio | 2 |
| Boynton Refining Co., Boynton, Okla. | 61 |
| British-American Oil Co, Toronto, Canada | 200 |
| E. A. Bush Co., Palmer, Mass. | 3 |
| Butler County Refining Co., Bruin, Pa. | 85 |
| Caddo Oil Refining Co., Shreveport, La. | 120 |
| Canfield Oil Refining Co., Coraopolis, Pa. | 45 |
| Canfield Tank Line, Cleveland, O. | 78 |
| Canfield Refining Co., Yale, Okla. | 55 |
| Cameron Refining Co., Ardmore, Okla. | 50 |
| Capital Refining Co., Buffalo, N. Y. | 47 |
| Carbo Refining Co., Guthrie, Okla. | 30 |
| Central Refining Co., Lawrenceville, Ill. | 293 |
| Champlin Oil & Refining Co., Enid, Okla. | 38 |

## OWNERSHIP OF TANK CARS—Continued

| Name and Location. | Tank Cars. |
|---|---|
| Chestnut & Smith, Tulsa, Okla | 12 |
| Cincinnati Oil Works, Cincinnati | 1 |
| Clarendon Refining Co., Clarendon, Pa | 75 |
| Cleveland Petroleum Refining Co., Cleveland, O | 21 |
| Climax Refining Co., Corsicana, Texas | 13 |
| Columbia Oil Co., New York | 39 |
| Commonwealth Refining Co., Moran, Kansas | 24 |
| Conewango Refining Co., Warren, Pa | 47 |
| Canadian Oil Companies, Ltd., Petrolia, Canada | 200 |
| Constantin Refining Co., Tulsa | 500 |
| Consumers Mutual Tank Line, Chicago | 88 |
| Consumers Refining Co., Cushing, Okla | 379 |
| Continental Oil Co., Denver | 8 |
| Continental Refining Co., Oil City, Pa | 50 |
| Continental Refining Co., Bristow, Okla | 50 |
| Cosden & Co., Tulsa | 2,163 |
| Craig Oil Co., Toledo, Ohio | 161 |
| Crescent Refining Co., Newkirk, Okla | 80 |
| Crew Levick Co., Philadelphia | 215 |
| Crown Gasoline & Oil Co., Pittsburgh, Pa | 2 |
| Crystal White Refining Co., Allen, Okla | 35 |
| Crystal Oil Works, Rouseville, Pa | 35 |
| Dallas Oil & Refining Co., Dallas, Texas | 20 |
| W. H. Daugherty & Son, Petrolia, Pa | 10 |
| El Dorado Refining Co., El Dorado, Kansas | 136 |
| Economy Oil & Refining Co., Blackwell, Okla | 68 |
| Elk Refining Co., Charleston, W. Va | 48 |
| Emery Mfg. Co., Bradford, Pa | 90 |
| Emlenton Refining Co., Emlenton, Pa | 74 |
| Empire Refineries, Tulsa | 2,100 |
| Empire Oil Works, Oil City, Pa | 980 |
| Ensign Oil Co., Norristown, Pa | 4 |
| Evans-Thwing | 250 |
| Foco Oil Co., Franklin, Pa | 25 |
| D. W. Frauchot Co., Tulsa, Okla | 12 |
| Franklin Quality Refining Co., Franklin, Pa | 10 |
| Freeport-Mex. Fuel Oil Corp., New Orleans, La | 350 |
| Freedom Oil Works, Freedom, Pa | 97 |
| General Refining Co., Tulsa | 70 |
| Glenn Pool Tank Line, Kansas City | 265 |
| Golden Rule Refinery, Wichita, Kansas | 30 |
| Great American Refining Co., Jennings, Okla | 116 |
| Great Western Oil Co., Cleveland | 21 |
| Great Western Oil Refining Co., Erie, Kansas | 86 |
| Gulf Refining Co., Pittsburgh, Pa | 1,411 |
| Gasoline Corporation, New York | 59 |
| General Petroleum Co., Los Angeles, Calif | 10 |
| Home Oil Refining Co., Yale, Okla | 195 |
| Great Lakes Oil & Refining Co., Wallaceburg, Can | 12 |
| Hillman Refining Co., Cushing, Okla | 49 |
| High Grade Petroleum Products Co., St. Mary's, W. Va | 50 |
| Humble Oil & Refining Co. (Dixie O. & F. Co.), San Antonio, Texas | 33 |
| Humboldt Refining Co., Humboldt, Kansas | 3 |
| Hutchinson Refining Co., Hutchinson, Kansas | 35 |
| Illinois Oil Co., Cushing, Okla | 75 |
| Illinois Refining Co., Rock Island, Ill | 61 |
| Imperial Refining Co., Ardmore, Okla | 26 |
| Imperial Oil Co., of Canada | 668 |
| Independent Refining Co., Oil City, Pa | 82 |
| Indiahoma Refining Co., St. Louis | 600 |
| Indian Refining Co., Lawrenceville, Ill | 1,032 |
| Inland Refining Co., Tulsa | 152 |
| International Oil Works, Ltd., St. Louis | 3 |
| International Refining Co., Tulsa | 418 |
| Inter-Ocean Oil Co., E. Brooklyn, Md | 15 |
| Interstate Oil Co., Minneapolis, Minn | 1 |
| Island Petroleum Co., Pittsburgh | 70 |
| Kansas City Oil Co., Kansas City, Kansas | 5 |

## OWNERSHIP OF TANK CARS—Continued

| Name and Location. | Tank Cars. |
|---|---|
| Kansas Oil Refining Co., Coffeyville, Kansas | 94 |
| Kansas City Refining Co., Kansas City, Kansas | 181 |
| Kansas Co-Operative Refining Co., Chanute, Kansas | 193 |
| Kendall Refining Co., Bradford, Pa | 28 |
| A. Knabb & Co., Marcus Hook, Pa | 1 |
| Lake Park Refining Co., Okmulgee, Okla | 205 |
| Lawton Refining Co., Lawton, Okla | 32 |
| Leader Oil Co., Casey, Ill | 13 |
| Lesh-National Refining Co., Arkansas City, Kansas | 45 |
| Liquified Petroleum Gas Co. Tulsa | 8 |
| Louisiana Oil Refining Co., Shreveport, La | 60 |
| Magnolia Petroleum Co., Dallas, Texas | 590 |
| Manufacturers Paraffine Co., Chester, Pa | 1 |
| Marland Refining Co., Ponca City, Okla | 320 |
| Marshall Oil Co., Marshalltown, Ia | 7 |
| Mexican Petroleum Co., Ltd., New York | 170 |
| Mid-Co Gasoline Co., Tulsa | 166 |
| Mid-Continent Oil Refining Co., East St. Louis, Ill | 14 |
| Mid-Continent Gasoline Co. Tulsa | 166 |
| Midland Refining Co., Eldorado, Kansas | 148 |
| Midwest Refining Co., Denver | 22 |
| Miller's Oil Refining Works, Allegheny, Pa | 44 |
| Miller Petroleum Refining Co., Chanute, Kansas | 59 |
| Milliken Refining Co., St. Louis | 70 |
| Motor Fuel Co., Sapulpa, Okla | 24 |
| Muskogee Refining Co., Muskogee, Okla | 150 |
| Mutual Oil Co., Kansas City, Mo | 82 |
| Mutual Refining Co., Ltd., Warren, Pa | 39 |
| National Oil Co., New York | 24 |
| New Haven Gas Light Co., New Haven, Conn | 5 |
| North American Refiners Co., Oklahoma City | 415 |
| Oconee Oil Refining Co., Athens, Ga | 10 |
| Ohio Valley Refining Co., St. Mary's, W. Va | 50 |
| Oil Products Corp., New York | 20 |
| O. K. Refining Co., Niotaze, Kansas | 161 |
| Oklahoma Petroleum & Gasoline Co., Tulsa | 41 |
| Oklahoma Refining Co., Oklahoma City | 93 |
| Okmulgee Products & Refining Co., Okmulgee, Okla | 20 |
| Oil State Refining Co, Enid, Okla | 30 |
| Oklahoma Products & Refining Co., Tulsa | 22 |
| Oneta Refining Co., Oneta, Okla | 31 |
| Oriental Oil Co., Dallas, Texas | 39 |
| Ozark Refining Co., Fort Smith, Ark | 13 |
| Ohio Cities Gas Co | 900 |
| National Refining Co., Cleveland | 1,004 |
| Pelican Oil Refining Co., New Orleans, La | 15 |
| Pennsylvania Refining Co., Oil City, Pa | 6 |
| Pennsylvania Refining Co., Karns City, Pa | 4 |
| Pan-American Refining Co., Tulsa | 260 |
| Panhandle Refining Co., Wichita Falls, Texas | 35 |
| Paragon Refining Co., Toledo, Ohio | 173 |
| Pawnee Refining Co., Oklahoma | 48 |
| Penn-American Refining Co., Oil City, Pa | 174 |
| Pennsylvania & Delaware Oil Co., New York | 19 |
| Pennsylvania Oil Products Oil Refining Co., Eldred, Pa | 35 |
| Petroleum Products Co., Pittsburgh | 12 |
| Phoenix Refining Co., Tulsa | 164 |
| Pierce-Fordyce Assn., Dallas, Texas | 403 |
| Pierce Oil Corp., St. Louis | 643 |
| Pinal Dome Refining Co., Santa Maria, Calif | 1 |
| Pittsburgh Oil Refining Co., Pittsburgh | 100 |
| Ponca Lub. Oil Co., Ponca City, Okla | 30 |
| Ponca Refining Co., Ponca City, Okla | 140 |
| Producers Refining Co., Oklahoma City | 270 |
| Prod. & Ref. Co., Blackwell, Okla | 136 |
| Frank Prox Co., Terre Haute, Ind | 5 |
| Prudential Oil Corp., Baltimore, Md | 250 |
| Puente Oil Co., Los Angeles | 2 |

## OWNERSHIP OF TANK CARS—Concluded

| Name and Location. | Tank Cars. |
|---|---|
| Pure Oil Co., Minneapolis, Minn. | 74 |
| Railroad Men's Refinery, Eldorado, Kansas | 3 |
| Record Oil Refining Co., New Orleans | 35 |
| Red "C" Oil Mfg. Co., Highland Town, Md | 92 |
| Richardson Lub. Co., Quincy, Ill. | 3 |
| Richfield Oil Co., Los Angeles | 10 |
| Riverside Western Oil Co., Tulsa | 225 |
| Roxana Petroleum Corp., Tulsa | 400 |
| Robinson Oil Refining Co., Robinson, Ill. | 9 |
| Rosedale Refining Co., Rosedale, Kansas | 90 |
| Rucker Bros., Everett, Washington | 2 |
| Sapulpa Refining Co., Sapulpa, Okla | 441 |
| Sarco Petroleum Products Co., Independence, Kansas | 183 |
| Seneca Oil Works, Warren, Pa | 67 |
| Sinclair Refining Co., Chicago | 3,700 |
| Levi Smith, Ltd., Clarendon, Pa | 18 |
| Shell Co. of California, San Francisco | 84 |
| Southern Oil Corp., Tulsa | 250 |
| Standard Oil Co (Union Tank) | 21,600 |
| Stannard, C. A., Emporia, Kansas | 14 |
| Starlight Refining Co., Karns City, Pa | 5 |
| Sterling Oil & Refining Co., Wichita, Kansas | 36 |
| St. Louis Oil & Refining Co., El Dorado, Kansas | 25 |
| Southern Alberta Refineries, Ltd., Okotoks, Alta | 1 |
| Southern Refining Co., Los Angeles | 2 |
| A. Speare's Sons Co., Boston | 6 |
| Superior Oil Works, Ltd., Warren, Pa | 25 |
| Superior Refining Co., Covington, Okla | 18 |
| Terminal Oil Refining Co., Healdton, Okla | 18 |
| The Texas Co., Houston, Texas | 3,435 |
| Tiona Refining Co. Clarendon, Pa | 5 |
| Titusville Oil Works, Titusville, Pa | 50 |
| Turner Oil Co., Los Angeles | 9 |
| Uncle Sam Oil Co., Cherryvale, Kansas | 51 |
| Union Oil Co. of California, Los Angeles | 115 |
| Union Petroleum Co., Philadelphia | 105 |
| Union Refining Co., East St. Louis, Ill. | 3 |
| United O. & R. Co., Beaumont, Texas | 5 |
| United Oil Co., Denver | 19 |
| United Refining Co., Warren, Pa | 40 |
| U. S. Asphalt Co., E. Brooklyn, Md | 300 |
| Upson's Oil & Soap Co., Parkersburg, W. Va | 7 |
| Valley Refining Co., Tulsa | 23 |
| Valvoline Oil Works, Ltd., East Butler, Pa | 89 |
| Victor Refining Co., Yale, Okla | 10 |
| Vulcan Oil Refining Co., Cleveland, O. | 48 |
| Wabash Refining Co., Robinson, Ill. | 88 |
| Wadhams Oil Co., Milwaukee | 5 |
| Warren Oil Co., Warren, Pa | 50 |
| Warren Refining Co., Warren, Pa | 106 |
| Waverly Oil Co., Pittsburgh | 50 |
| Webster Oil & Gas Co., Yale, Okla | 5 |
| Webster Refining Co., Humboldt, Kansas | 4 |
| Western Refining Co., Wichita, Kansas | 22 |
| West Virginia Oil Co., Parkersburg, W. Va | 1 |
| Wichita Independent Oil & Refg. Co. (Sterling), Wichita, Kansas | 115 |
| Wilburine Oil Works, Ltd., Warren, Pa | 61 |
| Wilhoit Refining Co., Springfield, Mo | 51 |
| Wilshire Oil Co | 50 |
| White Eagle Petroleum Co., Augusta, Kansas | 260 |
| Wright Pro. & Refining Co., Cherryvale, Kansas | 11 |
| Yaryan Rosin & Turpentine Co., Brunswick, Ga | 5 |
| Car manufacturers | 7,969 |
| Total | 65,500 |

## RULES GOVERNING THE LOCATION OF LOADING RACKS AND UNLOADING POINTS FOR CASINGHEAD GASOLINE, REFINERY GASOLINE, NAPHTHA OR ANY INFLAMMABLE LIQUID WITH FLASH POINT BELOW 30 DEG. F. (Temporarily Suspended.)

The location of loading racks and unloading points for volatile inflammable liquids is considered of great importance to the safety of railroad property, and there is at present lack of uniformity in the enforcement of proper safeguards for the protection of life and property. The following rules shall govern all carriers under Federal control with respect to the location of loading racks or unloading points hereafter installed. As to present locations these rules shall be observed when practicable, and for locations not in accordance therewith carrier through its proper officer shall submit report with recommendation covering each such location to the director of the Division of Operation for instruction. Whenever practicable, throug co-operation with the owners of such loading or unloading faciliti efforts will be made to secure their removal to a safe distance, such other remedy as the facts may justify will be applied.

### Loading

1. Loading racks for refinery gasoline, benzine, naphtha or any liquid with flash point below 30°F, must not be located nearer t eighty feet to a track over which trains or engines are operat (This does not apply to the track serving the loading rack.) Loa racks for casinghead gasoline or casinghead blends must be loc not less than 160 feet distance from such tracks, whenever practica and in no case should they be located at a less distance than 100 fe These rules apply to casinghead condensates or blends whether made by the compression or absorption process.

### Unloading

2. a. The unloading of tank cars of casinghead gasoline, benzine, naphtha and similar petroleum products on railroad sidings must not be permitted, except where facilities exist for piping the contents from the tank cars to permanent storage tanks.

b. The part of any siding on which tank cars of gasoline, benzine, naphtha, or any liquid with flash point below 30°F are to be unloaded, must be located not less than 80 feet from a track over which trains or engines are operated. (This does not apply to the track serving the unloading point.) Where casinghead gasoline is to be unloaded the unloading point must be not less than 160 feet from such track, whenever practicable, but in no case should the distance be less than 100 feet.

c. If the unloading is done on a private siding into tank wagons, barrels or drums (not permanently located storage tanks) the distance at which this operation is permitted must not be less than 160 feet.

d. If tank cars of refinery gasoline, benzine, naphtha, or any liquid with flash point below 30°F are loaded or unloaded at a place within 80 feet from a track over which trains or engines are operated, such tank cars must be provided with a dome cover equipped with

a vent line to liberate any escaping vapors. This vent line must be carried to a point at least 80 feet distant from such track. For casinghead gasoline 160 feet will be required whenever practicable, but in no case shall the distance be less than 100 feet from the center of track over which trains or engines are operated. The end of the vent line must be covered with a proper screen of not less than 20x20 mesh.

**Storage**

3. a. Gasoline, benzine, naphtha, or any liquid with flash point below 30°F, when stored in properly constructed tanks, is comparatively safe. The following regulations will apply for the construction and location of such storage tanks:

b. These regulations apply only to above ground tanks. Underground tanks should be considered separately as occasion may arise. All storage tanks will be considered above ground unless they are buried so that the top of the tank is covered with at least three feet of earth.

c. All tanks should be set upon a firm foundation and be electrically grounded.

d. Each tank over 1,000 gallons in capacity should have all manholes, hand holes, vent openings, and other openings which may contain inflammable vapor, provided with 20x20 mesh brass wire screen or its equivalent, so attached as to completely cover the openings and be protected against clogging; these screens may be made removable but should be kept, normally, firmly attached. Such a tank should also be vented or provided with a suitable safety valve set to operate at not more than five pounds per square inch for both interior pressure and vacuum; manhole covers kept closed by their weight only will be considered satisfactory.

e. Tanks used with a pressure system may have a safety valve set at not more than one-half the pressure to which the tank was originally tested.

f. Tanks containing over 500 gallons and not exceeding 48,000 gallons of gasoline, benzine, naphtha, or any liquid with flash point below 30°F, should be located not less than 80 feet from a track over which trains or engines are operated.

g. For capacities exceeding 48,000 gallons the following distances shall govern:

| Capacity of Tanks. (In gallons.) | Distance from Railroad Tracks or Property, Feet. | Distance from Other Tanks, Feet. |
|---|---|---|
| 48,001 to 75,000 | 85 | 3 |
| 75,001 to 100,000 | 100 | 15 |
| 100,001 to 150,000 | 150 | 25 |
| 150,001 to 250,000 | 250 | 35 |
| 250,001 to 500,000 | 300 | 50 |
| 500,001 to 1,000,000 | 350 | 75 |
| Unlimited | 400 | 200 |

h. The above distances should be doubled for tanks containing casinghead gasoline or casinghead blends.

i. Where practicable, tanks should be located on ground sloping away from railroad property, if this is impracticable, then the tanks

should be surrounded by dikes of earth, or concrete, or other suitable material, of sufficient capacity to hold all the contents of the tanks, or of such nature and location that in case of breakage of the tanks the oil will be diverted to point such that railway property and passing trains will not be endangered.

**General**

4. a. In measuring distances from any railroad track the center line of the track should be considered as the starting point.

b. During the time that the tank car is connected by loading or unloading connections, there must be signs placed on the track or car so as to give necessary warning. Such signs must be at least 12x15 inches in size and bear the words "Stop—Tank Car Connected," the word "STOP" being in letters at least 4 inches high and the other words in letters at least two inches high. The printing must be in white letters on a blue background.

c. In laying pipelines on railroad property for the loading or unloading of tank cars, they should be laid at a depth of at least three feet, and at points where such pipelines pass under tracks they should be laid at least four feet below the bottom of the ties.

d. All connections between tank cars and storage tanks must be in good condition, and must not permit any leakage. They must be frequently examined and replaced when they have become worn in order to insure at all times absolutely tight connections. Rubber, leather, or fabric hose must not be used. Tank cars must not be left connected to pipelines except when loading or unloading is going on and while a competent man is present and in charge.

e. Goose-necks, when used for loading and unloading tank cars, must be so constructed that when not in use they will automatically assume a stable position that will provide a horizontal clearance of not less than eight (8) feet from center line of track and be locked in that position. Where this method of unloading is used the rack supporting standpipe and goose-neck shall be of non-combustible material.

f. The ends of pipelines for loading or unloading tank cars from their bottom opening should be placed in shallow pits with brick or concrete walls not closer than 8 feet from center line of track. These pits should be ventilated and be protected by substantial one-piece covers, level with the surface of the ground, which must be kept locked in place when the pits are not in use. These pits should not be drained into a sewer or running stream.

g. The loading or unloading of tank cars should not be permitted except during daylight, when artificial light is not required. The presence of nearby switch lights, lanterns, or other exposed lights or fires during the process of loading or unloading is prohibited.

The following table is used in the calculation of capacities of reservoirs and tanks and in quickly converting different measures of petroleum and water into each other.

## MEASUREMENT OF WATER AND PETROLEUM AT 60° F

Multiply or divide, as required, the weight-measure values by the specific gravity of the petroleum. Specific gravity of average crude oil=0.850; fuel oil=0.900; gasoline=0.750; kerosene=0.820; gas oil=0.850.

| | Cubic Foot | Cubic Inch | U. S. Gallon | Imperial Gallon | Liter | Petroleum Barrel | Pound | Kilo-gram | Metric Ton |
|---|---|---|---|---|---|---|---|---|---|
| Cubic foot. . ...... | 1.000 | 1728. | 7.48 | 6.23 | 28.317 | 0.1781 | 62.37 | 28.29 | .02829 |
| Cubic inch. . ...... | .0005787 | 1.000 | .004329 | .003605 | .016387 | $1.303.10^{-4}$ | .03609 | .01637 | $1.637.10^{-5}$ |
| U. S. Gallon........ | .13367 | 231. | 1.000 | .8328 | 3.785 | .02381 | 8.338 | 3.782 | .003782 |
| Imperial Gallon. . . | .1605 | 277.4 | 1.201 | 1.000 | 4.545 | .02859 | 10.01 | 4.541 | .004541 |
| Liter. . . .......... | .03532 | 61.03 | .2642 | .2200 | 1.000 | .00629 | 2.203 | .999034 | .000999 |
| Petroleum Barrel .. | 5.615 | 9703. | 42.00 | 34.98 | 159.3 | 1.000 | 350.2 | 158.85 | .15885 |
| Pound (Av.). . .... | .01603 | 277.1 | .1199 | .0999 | .4539 | .002856 | 1.000 | .45359 | .0004536 |
| Kilogram. . . ....... | .03535 | 61.08 | .2644 | .2202 | 1.001 | .006296 | 2.205 | 1.000 | .001 |
| Metric ton. . . ..... | 35.35 | 61080. | 264.4 | 220.2 | 1001. | 6.296 | 2205. | 1000. | 1.000 |
| Pood (Russian). . . | .5791 | 1000. | 4.331 | 3.607 | 16.40 | 0.1031 | 36.12 | 16.38 | .01638 |

1 Koku (Jap) = 4.756 gal. 1 Piculi (Jap) = 133⅓ lbs. 1 Yen = 0.498 cts.

# Horizontal Cylindrical Tanks

C = Liquid contents in gallons
L = Length of tank in inches
d = Diameter of tank in inches
x = Depth of liquid contents in inches

$$C = \frac{L}{231}\left(0.004363\ d^2\ \mathrm{Cos}^{-1}\ \frac{d-2x}{d} - \frac{d-2x}{2}\sqrt{x(d-x)}\right)$$

$\mathrm{Cos}^{-1}\ \frac{d-2x}{d}$ means the value of the angular degrees whose cosine is $\frac{d-2x}{d}$

The cosine of an angle is the ratio in its right angled triangle, of the side adjacent the angle to the hypothenuse of the triangle.

When L = 300 inches
d = 100 inches
x = 30 inches

$$\frac{d-2x}{d} = .4$$

$\mathrm{Cos}^{-1}\ .4 = 66.42°$ (From Trigonometric tables)

$$C = \frac{300}{231}\left(0.004363\ (10000)\ (66.42) - 20\sqrt{2100}\right)$$

$$= \frac{300}{231}\ (2897 - 882.)$$

$$= 2617 \text{ gallons.}$$

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Total capacity of horizontal cylindrical tank in gallons.
C = $.0034\ d^2L$
d = diameter in inches. L = length in inches.
c = capacity in U. S. Gallons.

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Total capacity of horizontal cylindrical tanks in barrels.

C = $0.14\ d^2L$.
d = diameter in feet.
L = Length in feet.
c = capacity in barrels.

# Horizontal Cylindrical Tank Capacity Table

| Diameter | | Capacity | Capacity | | Diameter |
|---|---|---|---|---|---|
| 1% | = | .17% | 1% | = | 3.3% |
| 2% | = | .48% | 2% | = | 5.2% |
| 3% | = | .87% | 3% | = | 7.0% |
| 4% | = | 1.34% | 4% | = | 8.2% |
| 5% | = | 1.87% | 5% | = | 9.7% |
| 6% | = | 2.45% | 6% | = | 11.0% |
| 7% | = | 3.08% | 7% | = | 12.2% |
| 8% | = | 3.75% | 8% | = | 13.4% |
| 9% | = | 4.46% | 9% | = | 14.5% |
| 10% | = | 5.20% | 10% | = | 15.6% |
| 11% | = | 5.98% | 11% | = | 16.7% |
| 12% | = | 6.79% | 12% | = | 17.8% |
| 13% | = | 7.64% | 13% | = | 18.8% |
| 14% | = | 8.51% | 14% | = | 19.8% |
| 15% | = | 9.41% | 15% | = | 20.8% |
| 16% | = | 10.33% | 16% | = | 21.7% |
| 17% | = | 11.27% | 17% | = | 22.6% |
| 18% | = | 12.24% | 18% | = | 23.6% |
| 19% | = | 13.23% | 19% | = | 24.5% |
| 20% | = | 14.24% | 20% | = | 25.4% |
| 21% | = | 15.27% | 21% | = | 26.3% |
| 22% | = | 16.31% | 22% | = | 27.2% |
| 23% | = | 17.37% | 23% | = | 21.8% |
| 24% | = | 18.45% | 24% | = | 29.0% |
| 25% | = | 19.55% | 25% | = | 29.8% |
| 26% | = | 20.66% | 26% | = | 30.6% |
| 27% | = | 21.78% | 27% | = | 31.5% |
| 28% | = | 22.92% | 28% | = | 32.4% |
| 29% | = | 24.07% | 29% | = | 33.2% |
| 30% | = | 25.23% | 30% | = | 34.0% |
| 31% | = | 26.40% | 31% | = | 34.8% |
| 32% | = | 27.58% | 32% | = | 35.7% |
| 33% | = | 28.78% | 33% | = | 36.5% |
| 34% | = | 29.98% | 34% | = | 37.3% |
| 35% | = | 31.19% | 35% | = | 38.1% |
| 36% | = | 32.41% | 36% | = | 38.9% |
| 37% | = | 33.63% | 37% | = | 39.7% |
| 38% | = | 34.87% | 38% | = | 40.5% |
| 39% | = | 36.11% | 39% | = | 41.3% |
| 40% | = | 37.35% | 40% | = | 42.1% |
| 41% | = | 38.60% | 41% | = | 42.9% |
| 42% | = | 39.86% | 42% | = | 43.7% |
| 43% | = | 41.12% | 43% | = | 44.5% |
| 44% | = | 42.38% | 44% | = | 45.3% |
| 45% | = | 43.64% | 45% | = | 46.1% |
| 46% | = | 44.91% | 46% | = | 46.9% |
| 47% | = | 46.18% | 47% | = | 47.7% |
| 48% | = | 47.45% | 48% | = | 48.5% |
| 49% | = | 48.73% | 49% | = | 49.2% |
| 50% | = | 50.00% | 50% | = | 50.0% |

# Tank Car Outage Table

**Showing Capacity of an 8,000-Gallon Tank Car at Different Levels**

| Wet Reading Ft. | In. | Contents U. S. Gal. | Wet Reading Ft. | In. | Contents U. S. Gal. | Wet Reading Ft. | In. | Contents U. S. Gal. |
|---|---|---|---|---|---|---|---|---|
| .. | 1 | 20.4 | 3 | 4 | 4160. | 6 | 7 | 8084. |
| .. | 2 | 63.7 | 3 | 5 | 4293. | 6 | 8 | 8093.8 |
| .. | 3 | 102. | 3 | 6 | 4424. | 6 | 9 | 8103.74 |
| .. | 4 | 157. | 3 | 7 | 4554. | 6 | 10 | 8113.66 |
| .. | 5 | 218. | 3 | 8 | 4684. | 6 | 11 | 8123.57 |
| .. | 6 | 285. | 3 | 9 | 4814. | 7 | 0 | 8133.49 |
| .. | 7 | 356.5 | 3 | 10 | 4945. | 7 | 1 | 8143.4 |
| .. | 8 | 434.6 | 3 | 11 | 5073. | 7 | 2 | 8153.32 |
| .. | 9 | 516.7 | 4 | 0 | 5201. | 7 | 3 | 8163.23 |
| .. | 10 | 602. | 4 | 1 | 5330. | 7 | 4 | 8173.14 |
| .. | 11 | 692.2 | 4 | 2 | 5456. | 7 | 5 | 8183.06 |
| 1 | 0 | 785.5 | 4 | 3 | 5582. | 7 | 6 | 8192.97 |
| 1 | 1 | 881.3 | 4 | 4 | 5705. | 7 | 7 | 8202.89 |
| 1 | 2 | 981.1 | 4 | 5 | 5829. | 7 | 8 | 8213.05 |
| 1 | 3 | 1082. | 4 | 6 | 5950. | 7 | 9 | 8223.97 |
| 1 | 4 | 1187. | 4 | 7 | 6071. | 7 | 10 | 8234.88 |
| 1 | 5 | 1296. | 4 | 8 | 6191. | 7 | 11 | 8245.04 |
| 1 | 6 | 1456. | 4 | 9 | 6308. | 8 | 0 | 8254.96 |
| 1 | 7 | 1518. | 4 | 10 | 6424. | 8 | 1 | 8264.87 |
| 1 | 8 | 1630. | 4 | 11 | 6536. | 8 | 2 | 8274.79 |
| 1 | 9 | 1746. | 5 | 0 | 6649. | 8 | 3 | 8284.7 |
| 1 | 10 | 1863. | 5 | 1 | 6758. | 8 | 4 | 8294.62 |
| 1 | 11 | 1983. | 5 | 2 | 6867. | 8 | 5 | 8304.53 |
| 2 | 0 | 2104. | 5 | 3 | 6972. | 8 | 6 | 8314.45 |
| 2 | 1 | 2225. | 5 | 4 | 7073. | 8 | 7 | 8324.36 |
| 2 | 2 | 2349. | 5 | 5 | 7173. | 8 | 8 | 8334.28 |
| 2 | 3 | 2472. | 5 | 6 | 7269. | 8 | 9 | 8342.29 |
| 2 | 4 | 2598. | 5 | 7 | 7362. | 8 | 10 | 8346.98 |
| 2 | 5 | 2724. | 5 | 8 | 7452.08 | 8 | 11 | 8349.48 |
| 2 | 6 | 2853. | 5 | 9 | 7538.32 | 9 | 0 | 8351.98 |
| 2 | 7 | 2981. | 5 | 10 | 7620.07 | 9 | 1 | 8354.48 |
| 2 | 8 | 3109. | 5 | 11 | 7699.34 | 9 | 2 | 8356.98 |
| 2 | 9 | 3240. | 6 | 0 | 7771.36 | 9 | 3 | 8359.49 |
| 2 | 10 | 3370. | 6 | 1 | 7839.86 | 9 | 4 | 8361.49 |
| 2 | 11 | 3500. | 6 | 2 | 7902.96 | 9 | 5 | 8362.70 |
| 3 | 0 | 3630. | 6 | 3 | 7960.76 | 9 | 6 | 8363.31 |
| 3 | 1 | 3761. | 6 | 4 | 8002.86 | 9 | 7 | 8363.93 |
| 3 | 2 | 3894. | 6 | 5 | 8051.24 | 9 | 8 | 8364.54 |
| 3 | 3 | 4027. | 6 | 6 | 8074. | | | |

## GAUGING TABLE FOR EACH ONE-QUARTER INCH IN DEPTH FOR TANK AS DETAILED ON PETROLEUM IRON WORKS COMPANY DRAWING No. 2050-A

### 8050-Gallon 78-Inch Diameter Tank With Steam Coils for Type "A" and "A-1" Cars

| Depth | Bottom | Feet | Gallons | Feet | Gallons | Feet | Gallons | Feet | Gallons | Feet | Gallons | Feet | Gallons | Feet | Gallons |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .... | 1 | 731 | 2 | 2037 | 3 | 3565 | 4 | 5142 | 5 | 6583 | 6 | 7695 | 7 | 8085 |
| ¼ | .... | ¼ | 754 | ¼ | 2067 | ¼ | 3598 | ¼ | 5174 | ¼ | 6611 | ¼ | 7713 | ¼ | 8088 |
| ½ | .... | ½ | 777 | ½ | 2097 | ½ | 3631 | ½ | 5206 | ½ | 6638 | ½ | 7731 | ½ | 8091 |
| ¾ | .... | ¾ | 801 | ¾ | 2128 | ¾ | 3664 | ¾ | 5238 | ¾ | 6665 | ¾ | 7749 | ¾ | 8094 |
| 1 | 20 | 1 | 825 | 1 | 2159 | 1 | 3697 | 1 | 5269 | 1 | 6692 | 1 | 7766 | 1 | 8097 |
| ¼ | 28 | ¼ | 849 | ¼ | 2189 | ¼ | 3730 | ¼ | 5301 | ¼ | 6719 | ¼ | 7783 | ¼ | 8100 |
| ½ | 37 | ½ | 875 | ½ | 2220 | ½ | 3765 | ½ | 5332 | ½ | 6746 | ½ | 7800 | ½ | 8103 |
| ¾ | 46 | ¾ | 898 | ¾ | 2251 | ¾ | 3796 | ¾ | 5364 | ¾ | 6772 | ¾ | 7816 | ¾ | 8106 |
| 2 | 55 | 2 | 823 | 2 | 2282 | 2 | 3830 | 2 | 5395 | 2 | 6798 | 2 | 7832 | 2 | 8109 |
| ¼ | 65 | ¼ | 948 | ¼ | 2313 | ¼ | 3863 | ¼ | 5427 | ¼ | 3824 | ¼ | 7847 | ¼ | 8112 |
| ½ | 76 | ½ | 973 | ½ | 2344 | ½ | 3896 | ½ | 5458 | ½ | 6850 | ½ | 7862 | ½ | 8115 |
| ¾ | 88 | ¾ | 998 | ¾ | 2375 | ¾ | 3929 | ¾ | 5489 | ¾ | 6876 | ¾ | 7877 | ¾ | 8118 |
| 3 | 100 | 3 | 1024 | 3 | 2406 | 3 | 3963 | 3 | 5520 | 3 | 6901 | 3 | 7891 | 3 | 8120 |
| ¼ | 113 | ¼ | 1050 | ¼ | 2437 | ¼ | 3997 | ¼ | 5551 | ¼ | 6927 | ¼ | 7905 | ¼ | 8123 |
| ½ | 126 | ½ | 1076 | ½ | 2468 | ½ | 4030 | ½ | 5582 | ½ | 6952 | ½ | 7918 | ½ | 8126 |
| ¾ | 139 | ¾ | 1102 | ¾ | 2499 | ¾ | 4063 | ¾ | 5613 | ¾ | 6977 | ¾ | 7931 | ¾ | 8129 |
| 4 | 153 | 4 | 1128 | 4 | 2531 | 4 | 4096 | 4 | 5644 | 4 | 7002 | 4 | 7943 | 4 | 8132 |
| ¼ | 167 | ¼ | 1154 | ¼ | 2562 | ¼ | 4130 | ¼ | 5675 | ¼ | 7027 | ¼ | 7954 | ¼ | 8135 |
| ½ | 181 | ½ | 1180 | ½ | 2594 | ½ | 4163 | ½ | 5706 | ½ | 7052 | ½ | 7965 | ½ | 8138 |
| ¾ | 196 | ¾ | 1207 | ¾ | 2625 | ¾ | 4196 | ¾ | 5737 | ¾ | 7077 | ¾ | 7976 | ¾ | 8141 |
| 5 | 211 | 5 | 1234 | 5 | 2657 | 5 | 4229 | 5 | 5767 | 5 | 7101 | 5 | 7986 | 5 | 8144 |
| ¼ | 226 | ¼ | 1261 | ¼ | 2688 | ¼ | 4262 | ¼ | 5799 | ¼ | 7125 | ¼ | 7995 | ¼ | 8147 |
| ½ | 241 | ½ | 1288 | ½ | 2720 | ½ | 4295 | ½ | 5829 | ½ | 7149 | ½ | 8003 | ½ | 8150 |
| ¾ | 256 | ¾ | 1315 | ¾ | 2752 | ¾ | 4328 | ¾ | 5859 | ¾ | 7173 | ¾ | 8010 | ¾ | 8153 |
| 6 | 272 | 6 | 1343 | 6 | 2784 | 6 | 4361 | 6 | 5889 | 6 | 7197 | 6 | 8015 | 6 | 8155 |
| ¼ | 287 | ¼ | 1370 | ¼ | 2816 | ¼ | 4394 | ¼ | 5919 | ¼ | 7221 | ¼ | 8018 | ¼ | .... |
| ½ | 305 | ½ | 1398 | ½ | 2848 | ½ | 4427 | ½ | 5949 | ½ | 7244 | ½ | 8021 | ½ | .... |
| ¾ | 319 | ¾ | 1426 | ¾ | 2880 | ¾ | 4460 | ¾ | 5979 | ¾ | 7267 | ¾ | 8024 | ¾ | .... |
| 7 | 335 | 7 | 1454 | 7 | 2912 | 7 | 4493 | 7 | 6009 | 7 | 7290 | 7 | 8027 | 7 | .... |
| ¼ | 352 | ¼ | 1482 | ¼ | 2944 | ¼ | 4526 | ¼ | 6039 | ¼ | 7313 | ¼ | 8030 | ¼ | .... |
| ½ | 369 | ½ | 1510 | ½ | 2976 | ½ | 4559 | ½ | 6069 | ½ | 7335 | ½ | 8033 | ½ | .... |
| ¾ | 386 | ¾ | 1538 | ¾ | 3008 | ¾ | 4592 | ¾ | 6098 | ¾ | 7357 | ¾ | 8036 | ¾ | .... |
| 8 | 403 | 8 | 1567 | 8 | 3041 | 8 | 4624 | 8 | 6127 | 8 | 7379 | 8 | 8039 | 8 | .... |
| ¼ | 421 | ¼ | 1595 | ¼ | 3073 | ¼ | 4657 | ¼ | 6157 | ¼ | 7401 | ¼ | 8042 | ¾ | .... |
| ½ | 439 | ½ | 1624 | ½ | 3106 | ½ | 4690 | ½ | 6186 | ½ | 7422 | ½ | 8045 | ½ | .... |
| ¾ | 457 | ¾ | 1653 | ¾ | 3138 | ¾ | 4723 | ¾ | 6215 | ¾ | 7443 | ¾ | 8048 | ¾ | .... |
| 9 | 476 | 9 | 1682 | 9 | 3171 | 9 | 4755 | 9 | 6244 | 9 | 7484 | 9 | 8050 | 9 | .... |
| ¼ | 496 | ¼ | 1711 | ¼ | 3203 | ¼ | 4788 | ¼ | 6273 | ¼ | 7485 | ¼ | 8053 | ¼ | .... |
| ½ | 516 | ½ | 1740 | ½ | 3236 | ½ | 4820 | ½ | 6302 | ½ | 7506 | ½ | 8056 | ½ | .... |
| ¾ | 536 | ¾ | 1769 | ¾ | 3269 | ¾ | 4853 | ¾ | 6351 | ¾ | 7526 | ¾ | 8059 | ¾ | .... |
| 10 | 556 | 10 | 1799 | 10 | 3302 | 10 | 4885 | 10 | 6359 | 10 | 7546 | 10 | 8062 | 10 | .... |
| ¼ | 577 | ¼ | 1826 | ¼ | 3334 | ¼ | 4918 | ¼ | 6388 | ¼ | 7566 | ¼ | 8065 | ¼ | .... |
| ½ | 598 | ½ | 1857 | ½ | 3367 | ½ | 4950 | ½ | 6416 | ½ | 7585 | ½ | 8068 | ½ | .... |
| ¾ | 619 | ¾ | 1887 | ¾ | 3400 | ¾ | 4982 | ¾ | 6444 | ¾ | 7604 | ¾ | 8071 | ¾ | .... |
| 11 | 640 | 11 | 1917 | 11 | 3433 | 11 | 5014 | 11 | 6472 | 11 | 7623 | 11 | 8074 | 11 | .... |
| ¼ | 662 | ¼ | 1947 | ¼ | 3466 | ¼ | 5046 | ¼ | 6500 | ¼ | 7641 | ¼ | 8077 | ¼ | .... |
| ½ | 684 | ½ | 1977 | ½ | 3499 | ½ | 5078 | ½ | 6528 | ½ | 7659 | ½ | 8080 | ½ | .... |
| ¾ | 707 | ¾ | 2007 | ¾ | 3532 | ¾ | 5110 | ¾ | 6556 | ¾ | 7677 | ¾ | 8083 | ¾ | .... |

Steam Coils, Con.

Steam Coils 46 Gallons Deducted

DOME

DOME 244 gallons = 11.60 gallons to one inch.
Furnished by Pennsylvania Tank Car Company, Sharon, Pa.

# Tank Car Outage Tables*

**Calculated from 0.25 Inch to 5 Inches Out of Shell, at 60°F**
**Capacity of Car in Gallons at 60°F**

| Inches | 4231 Gallons | 6000 Gallons | 6641 Gallons | 7000 Gallons | 8087 Gallons | 8102 Gallons | 8505 Gallons | 10000 Gallons |
|---|---|---|---|---|---|---|---|---|
| 0.25 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 |
| 0.5 | 6 | 8 | 8 | 8 | 10 | 10 | 10 | 12 |
| 0.75 | 9 | 13 | 13 | 13 | 16 | 16 | 17 | 19 |
| 1. | 13 | 18 | 18 | 18 | 23 | 23 | 25 | 26 |
| 1.25 | 18 | 24 | 25 | 25 | 31 | 31 | 33 | 36 |
| 1.5 | 23 | 31 | 33 | 33 | 39 | 39 | 45 | 46 |
| 1.75 | 29 | 38 | 41 | 41 | 48 | 48 | 56 | 58 |
| 2. | 35 | 46 | 49 | 50 | 58 | 58 | 67 | 71 |
| 2.25 | 41 | 54 | 58 | 59 | 69 | 69 | 79 | 84 |
| 2.5 | 48 | 63 | 68 | 69 | 80 | 80 | 92 | 98 |
| 2.75 | 55 | 72 | 78 | 79 | 90 | 91 | 105 | 111 |
| 3. | 63 | 82 | 88 | 90 | 103 | 103 | 119 | 125 |
| 3.25 | 71 | 92 | 99 | 101 | 115 | 115 | 133 | 140 |
| 3.5 | 79 | 103 | 110 | 113 | 128 | 128 | 148 | 156 |
| 3.75 | 87 | 114 | 123 | 125 | 141 | 141 | 163 | 171 |
| 4. | 96 | 125 | 134 | 137 | 154 | 154 | 178 | 186 |
| 4.25 | 105 | 136 | 146 | 150 | 167 | 167 | 194 | 203 |
| 4.5 | 114 | 148 | 159 | 163 | 181 | 181 | 211 | 220 |
| 4.75 | 123 | 160 | 172 | 176 | 195 | 195 | 288 | 237 |
| 5. | 133 | 173 | 186 | 190 | 210 | 210 | 244 | 254 |

*Furnished by Phoenix Refining Co.

## CONTENTS OF HORIZONTAL TANKS (GALLONS).
Multiply Capacity in Tables by Length of Tanks in Inches.

| 36 Inches in Diameter | 37 Inches in Diameter | 38 Inches in Diameter | Depth Inches | 39 Inches in Diameter | 40 Inches in Diameter | 41 Inches in Diameter |
|---|---|---|---|---|---|---|
| ........... | ........... | ........... | 20½ | ........... | ........... | 2.858 |
| ........... | ........... | ........... | 20 | ........... | 2.720 | 2.769 |
| ........... | ........... | ........... | 19½ | 2.586 | ........... | ........... |
| ........... | ........... | 2.445 | 19 | 2.501 | 2.547 | 2.591 |
| ........... | 2.327 | ........... | 18½ | ........... | ........... | ........... |
| 2.203 | 2.247 | 2.290 | 18 | 2.332 | 2.374 | 2.415 |
| 2.047 | 2.087 | 2.126 | 17 | 2.165 | 2.202 | 2.239 |
| 1.893 | 1.928 | 1.963 | 16 | 1.998 | 2.032 | 2.065 |
| 1.739 | 1.770 | 1.801 | 15 | 1.832 | 1.863 | 1.894 |
| 1.585 | 1.613 | 1.643 | 14 | 1.669 | 1.697 | 1.724 |
| 1.434 | 1.459 | 1.484 | 13 | 1.509 | 1.533 | 1.557 |
| 1.286 | 1.308 | 1.330 | 12 | 1.351 | 1.372 | 1.393 |
| 1.140 | 1.159 | 1.179 | 11 | 1.198 | 1.216 | 1.233 |
| .999 | 1.015 | 1.032 | 10 | 1.047 | 1.063 | 1.079 |
| .861 | .875 | .889 | 9 | .903 | .916 | .929 |
| .729 | .740 | .752 | 8 | .763 | .774 | .785 |
| .603 | .612 | .621 | 7 | .631 | .639 | .648 |
| .483 | .490 | .497 | 6 | .505 | .512 | .518 |
| .371 | .376 | .382 | 5 | .387 | .392 | .398 |
| .268 | .271 | .275 | 4 | .280 | .283 | .287 |
| .175 | .178 | .180 | 3 | .183 | .185 | .188 |
| .096 | .098 | .099 | 2 | .100 | .102 | .103 |
| .034 | .035 | .035 | 1 | .036 | .036 | .037 |

## CONTENTS OF HORIZONTAL TANKS—Continued.

| 42 Inches in Diameter | 43 Inches in Diameter | 44 Inches in Diameter | Depth Inches | 45 Inches in Diameter | 46 Inches in Diameter | 47 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 23½ | ............ | ............ | 3.755 |
| ............ | ............ | ............ | 23 | ............ | 3.597 | 3.653 |
| ............ | ............ | ............ | 22½ | 3.442 | ............ | ............ |
| ............ | ............ | 3.291 | 22 | 3.344 | 3.397 | 3.450 |
| ............ | 3.143 | ............ | 21½ | ............ | ............ | ............ |
| 2.998 | 3.050 | 3.100 | 21 | 3.149 | 3.199 | 3.248 |
| 2.817 | 2.864 | 2.908 | 20 | 2.955 | 3.002 | 3.047 |
| 2.636 | 2.679 | 2.721 | 19 | 2.763 | 2.805 | 2.846 |
| 2.455 | 2.495 | 2.533 | 18 | 2.572 | 2.609 | 2.647 |
| 2.276 | 2.313 | 2.347 | 17 | 2.381 | 2.416 | 2.450 |
| 2.098 | 2.132 | 2.163 | 16 | 2.193 | 2.225 | 2.256 |
| 1.922 | 1.952 | 1.981 | 15 | 2.009 | 2.037 | 2.064 |
| 1.750 | 1.776 | 1.802 | 14 | 1.827 | 1.852 | 1.876 |
| 1.580 | 1.603 | 1.626 | 13 | 1.648 | 1.672 | 1.693 |
| 1.414 | 1.434 | 1.454 | 12 | 1.473 | 1.494 | 1.513 |
| 1.252 | 1.269 | 1.287 | 11 | 1.304 | 1.321 | 1.338 |
| 1.094 | 1.110 | 1.125 | 10 | 1.139 | 1.154 | 1.168 |
| .942 | .955 | .968 | 9 | .980 | .993 | 1.005 |
| .797 | .807 | .817 | 8 | .827 | .838 | .848 |
| .657 | .666 | .675 | 7 | .682 | .691 | .699 |
| .526 | .532 | .540 | 6 | .546 | .552 | .558 |
| .403 | .408 | .414 | 5 | .418 | .424 | .428 |
| .291 | .294 | .297 | 4 | .301 | .304 | .308 |
| .190 | .193 | .194 | 3 | .197 | .199 | .200 |
| .104 | .106 | .107 | 2 | .108 | .110 | .111 |
| .037 | .038 | .038 | 1 | .038 | .039 | .039 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tanks in Inches.

| 48 Inches in Diameter | 49 Inches in Diameter | 50 Inches in Diameter | Depth Inches | 51 Inches in Diameter | 52 Inches in Diameter | 53 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 26½ | ............ | ............ | 4.776 |
| ............ | ............ | ............ | 26 | ............ | 4.597 | 4.660 |
| ............ | ............ | ............ | 25½ | 4.422 | ............ | ............ |
| ............ | ............ | 4.250 | 25 | 4.309 | 4.371 | 4.431 |
| ............ | 4.082 | ............ | 24½ | ............ | ............ | ............ |
| 3 917 | 3.975 | 4.033 | 24 | 4.085 | 4.146 | 4.203 |
| 3.707 | 3.765 | 3.817 | 23 | 3.865 | 3.922 | 3.976 |
| 3.498 | 3.555 | 3.602 | 22 | 3.647 | 3.700 | 3.749 |
| 2.289 | 3.345 | 3.388 | 21 | 3.431 | 3.479 | 3.523 |
| 3.084 | 3.136 | 3.175 | 20 | 3.216 | 3.259 | 3.300 |
| 2.881 | 2.928 | 2.964 | 19 | 3.002 | 3.044 | 3.078 |
| 2.679 | 2.722 | 2.755 | 18 | 2.790 | 2.825 | 2.859 |
| 2.478 | 2.517 | 2.548 | 17 | 2.580 | 2.613 | 2.644 |
| 2.281 | 2.316 | 2.344 | 16 | 2.374 | 2.405 | 2.432 |
| 2.087 | 2.118 | 1.145 | 15 | 2.170 | 2.199 | 2.222 |
| 1.900 | 1.924 | 1.948 | 14 | 1.971 | 1.996 | 2.016 |
| 1.716 | 1.734 | 1.756 | 13 | 1.777 | 1.797 | 1.815 |
| 1.533 | 1.550 | 1.569 | 12 | 1.585 | 1.605 | 1.622 |
| 1.353 | 1.370 | 1.386 | 11 | 1.402 | 1.417 | 1.433 |
| 1.180 | 1.195 | 1.210 | 10 | 1.223 | 1.235 | 1.251 |
| 1.017 | 1.027 | 1.040 | 9 | 1.052 | 1.063 | 1.077 |
| .859 | .866 | .878 | 8 | .888 | .897 | .907 |
| .708 | .716 | .723 | 7 | .729 | .737 | .746 |
| .565 | .575 | .578 | 6 | .583 | .587 | .595 |
| .432 | .440 | .442 | 5 | .447 | .451 | .454 |
| .310 | .317 | .319 | 4 | .319 | .326 | .329 |
| .201 | .205 | .208 | 3 | .211 | .214 | .214 |
| .113 | .114 | .114 | 2 | .114 | .117 | .119 |
| .040 | .041 | .041 | 1 | .041 | .041 | .042 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tanks in Inches.

| 54 Inches in Diameter | 55 Inches in Diameter | 56 Inches in Diameter | Depth Inches | 57 Inches in Diameter | 58 Inches in Diameter | 59 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 29½ | ............ | ............ | 5.918 |
| ............ | ............ | ............ | 29 | ............ | 5.719 | 5.790 |
| ............ | ............ | ............ | 28½ | 5.523 | ............ | ............ |
| ............ | ............ | 5.331 | 28 | 5.399 | 5.467 | 5.535 |
| ............ | 5.143 | ............ | 27½ | ............ | ............ | ............ |
| 4.957 | 5.023 | 5.089 | 27 | 5.153 | 5.217 | 5.280 |
| 4.723 | 4.785 | 4.847 | 26 | 4.907 | 4.967 | 5.026 |
| 4.490 | 4.547 | 4.605 | 25 | 4.662 | 4.717 | 4.773 |
| 4.258 | 4.311 | 4.365 | 24 | 4.417 | 4.469 | 4.521 |
| 4.026 | 4.076 | 4.125 | 23 | 4.175 | 4.223 | 4.271 |
| 3.794 | 3.842 | 3.886 | 22 | 3.934 | 3.978 | 4.023 |
| 3.566 | 3.611 | 3.651 | 21 | 3.694 | 3.736 | 3.777 |
| 3.340 | 3.381 | 3.418 | 20 | 3.456 | 3.495 | 3.534 |
| 3.116 | 3.152 | 3.188 | 19 | 3.222 | 3.256 | 3.293 |
| 2.893 | 2.926 | 2.959 | 18 | 2.992 | 3.020 | 3.057 |
| 2.674 | 2.704 | 2.734 | 17 | 2.766 | 2.788 | 2.823 |
| 2.459 | 2.486 | 2.513 | 16 | 2.543 | 2.563 | 2.594 |
| 2.248 | 2.271 | 2.296 | 15 | 2.321 | 2.344 | 2.369 |
| 2.041 | 2.061 | 2.084 | 14 | 2.104 | 2.128 | 2.149 |
| 1.838 | 1.857 | 1.878 | 13 | 1.895 | 1.916 | 1.934 |
| 1.640 | 1.657 | 1.675 | 12 | 1.692 | 1.710 | 1.726 |
| 1.449 | 1.464 | 1.478 | 11 | 1.496 | 1.509 | 1.524 |
| 1.265 | 1.279 | 1.290 | 10 | 1.304 | 1.316 | 1.329 |
| 1.086 | 1.099 | 1.108 | 9 | 1.120 | 1.130 | 1.141 |
| .915 | .926 | .936 | 8 | .943 | .953 | .961 |
| .755 | .759 | .769 | 7 | .776 | .784 | .791 |
| .602 | .607 | .614 | 6 | .620 | .626 | .631 |
| .461 | .466 | .470 | 5 | .473 | .479 | .483 |
| .331 | .335 | .337 | 4 | .340 | .344 | .347 |
| .217 | .219 | .220 | 3 | .223 | .225 | .227 |
| .119 | .120 | .121 | 2 | .122 | .123 | .124 |
| .042 | .042 | .043 | 1 | .043 | .044 | .044 |

**HORIZONTAL TANKS.**
Multiply Capacity in Tables by Length of Tanks in Inches.

| 60 Inches in Diameter | 61 Inches in Diameter | 62 Inches in Diameter | Depth Inches | 63 Inches in Diameter | 64 Inches in Diameter | 65 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 32½ | ............ | ............ | 7.182 |
| ............ | ............ | ............ | 32 | ............ | 6.963 | 7.039 |
| ............ | ............ | ............ | 31½ | 6.747 | ............ | ............ |
| ............ | ............ | 6.535 | 31 | 6.610 | 6.686 | 6.755 |
| ............ | 6.326 | ............ | 30½ | ............ | ............ | ............ |
| 6.119 | 6.193 | 6.267 | 30 | 6.337 | 6.410 | 6.472 |
| 5.858 | 5.929 | 5.999 | 29 | 6.065 | 6.134 | 6.193 |
| 5.598 | 5.668 | 5.732 | 28 | 5.794 | 5.858 | 5.915 |
| 5.339 | 5.407 | 5.465 | 27 | 5.523 | 5.584 | 5.639 |
| 5.082 | 5.146 | 5.199 | 26 | 5.254 | 5.310 | 5.363 |
| 4.826 | 4.885 | 4.935 | 25 | 4.986 | 5.038 | 5.089 |
| 4.572 | 4.625 | 4.672 | 24 | 4.722 | 4.769 | 4.817 |
| 4.318 | 4.366 | 4.412 | 23 | 4.458 | 4.503 | 4.547 |
| 4.066 | 4.111 | 4.153 | 22 | 4.196 | 4.239 | 4.281 |
| 3.818 | 3.859 | 3.898 | 21 | 3.937 | 3.976 | 4.016 |
| 3.572 | 3.609 | 3.645 | 20 | 3.683 | 3.718 | 3.756 |
| 3.328 | 3.363 | 3.397 | 19 | 3.430 | 3.464 | 3.496 |
| 3.088 | 3.120 | 3.151 | 18 | 3.181 | 3.213 | 3.242 |
| 2.582 | 2.881 | 2.910 | 17 | 2.937 | 2.964 | 2.992 |
| 2.621 | 2.646 | 2.672 | 16 | 2.698 | 2.723 | 2.748 |
| 2.392 | 2.417 | 2.440 | 15 | 2.463 | 2.486 | 2.508 |
| 2.171 | 2.192 | 2.213 | 14 | 2.232 | 2.254 | 2.274 |
| 1.954 | 1.972 | 1.991 | 13 | 2.008 | 2.027 | 2.045 |
| 1.743 | 1.759 | 1.776 | 12 | 1.791 | 1.808 | 1.823 |
| 1.538 | 1.552 | 1.567 | 11 | 1.581 | 1.595 | 1.608 |
| 1.341 | 1.352 | 1.366 | 10 | 1.378 | 1.390 | 1.401 |
| 1.152 | 1.161 | 1.173 | 9 | 1.183 | 1.192 | 1.203 |
| .971 | .980 | .988 | 8 | .996 | 1.005 | 1.013 |
| .799 | .806 | .812 | 7 | .819 | .827 | .833 |
| .634 | .642 | .648 | 6 | .653 | .659 | .664 |
| .487 | .491 | .496 | 5 | .500 | .504 | .508 |
| .349 | .354 | .357 | 4 | .359 | .362 | .365 |
| .229 | .230 | .233 | 3 | .235 | .238 | .238 |
| .125 | .126 | .128 | 2 | .128 | .129 | .131 |
| .045 | .045 | .045 | 1 | .046 | .046 | .047 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tanks in Inches.

| 66 Inches in Diameter | 67 Inches in Diameter | 68 Inches in Diameter | Depth Inches | 60 Inches in Diameter | 70 Inches in Diameter | 71 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 35½ | ............ | ............ | 8.570 |
| ............ | ............ | ............ | 35 | ............ | 8.330 | 8.413 |
| ............ | ............ | ............ | 34½ | 8.094 | ............ | ............ |
| ............ | ............ | 7.861 | 34 | 7.944 | 8.026 | 8.107 |
| ............ | 7.631 | ............ | 33½ | ............ | ............ | ............ |
| 7.406 | 7.485 | 7.567 | 33 | 7.646 | 7.723 | 7.801 |
| 7.120 | 7.194 | 7.273 | 32 | 7.348 | 7.421 | 7.495 |
| 6.834 | 6.904 | 6.979 | 31 | 7.051 | 7.120 | 7.190 |
| 6.549 | 6.617 | 6.687 | 30 | 6.755 | 6.819 | 6.886 |
| 6.264 | 6.327 | 6.395 | 29 | 6.459 | 6.519 | 6.583 |
| 5.981 | 6.041 | 6.104 | 28 | 6.164 | 6.222 | 6.283 |
| 5.699 | 5.756 | 5.814 | 27 | 5.870 | 5.927 | 5.983 |
| 5.419 | 5.473 | 5.528 | 26 | 5.580 | 5.634 | 5.686 |
| 5.141 | 5.191 | 5.244 | 25 | 5.292 | 5.343 | 5.391 |
| 4.865 | 4.913 | 4.961 | 24 | 5.006 | 5.052 | 5.098 |
| 4.592 | 4.637 | 4.681 | 23 | 4.724 | 4.764 | 4.809 |
| 4.322 | 4.363 | 4.403 | 22 | 4.444 | 4.481 | 4.524 |
| 4.054 | 4.092 | 4.128 | 21 | 4.167 | 4.204 | 4.241 |
| 3.789 | 3.824 | 3.859 | 20 | 3.893 | 3.929 | 3.962 |
| 3.529 | 3.561 | 3.593 | 19 | 3.625 | 3.657 | 3.688 |
| 3.273 | 3.302 | 3.331 | 18 | 3.360 | 3.388 | 3.418 |
| 3.020 | 3.046 | 3.074 | 17 | 3.101 | 3.125 | 3.152 |
| 2.772 | 2.797 | 2.821 | 16 | 2.846 | 2.868 | 2.894 |
| 2.530 | 2.553 | 2.575 | 15 | 2.595 | 2.617 | 2.640 |
| 2.294 | 2.314 | 2.333 | 14 | 2.352 | 2.372 | 2.391 |
| 2.064 | 2.080 | 2.099 | 13 | 2.116 | 2.135 | 2.150 |
| 1.839 | 1.855 | 1.871 | 12 | 1.886 | 1.901 | 1.916 |
| 1.622 | 1.635 | 1.650 | 11 | 1.663 | 1.674 | 1.693 |
| 1.413 | 1.426 | 1.439 | 10 | 1.449 | 1.459 | 1.476 |
| 1.213 | 1.223 | 1.235 | 9 | 1.242 | 1.254 | 1.264 |
| 1.022 | 1.030 | 1.041 | 8 | 1.047 | 1.060 | 1.063 |
| .841 | .847 | .855 | 7 | .859 | .871 | .874 |
| .670 | .675 | .680 | 6 | .687 | .689 | .697 |
| .512 | .516 | .529 | 5 | .524 | .528 | .531 |
| .368 | .371 | .374 | 4 | .377 | .378 | .382 |
| .240 | .243 | .244 | 3 | .246 | 249 | .250 |
| .131 | .132 | .133 | 2 | .134 | .135 | .136 |
| .047 | .047 | .047 | 1 | .048 | .048 | .048 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tanks in Inches.

| 72 Inches in Diameter | 73 Inches in Diameter | 74 Inches in Diameter | Depth Inches | 75 Inches in Diameter | 76 Inches in Diameter | 77 Inches in Diameter |
|---|---|---|---|---|---|---|
| ........... | ........... | ........... | 38½ | ........... | ........... | 10.079 |
| ........... | ........... | ........... | 38 | ........... | 9.819 | 9.912 |
| ........... | ........... | ........... | 37½ | 9.562 | ........... | ........... |
| ........... | ........... | 9.309 | 37 | 9.400 | 9.489 | 9.579 |
| ........... | 9.059 | ........... | 36½ | ........... | ........... | ........... |
| 8.813 | 8.899 | 8.989 | 36 | 9.076 | 9.160 | 9.246 |
| 8.500 | 8.582 | 8.669 | 35 | 8.752 | 8.832 | 8.914 |
| 8.188 | 8.267 | 8.349 | 34 | 8.428 | 8.505 | 8.583 |
| 7.887 | 7.953 | 8.030 | 33 | 8.104 | 8.178 | 8.253 |
| 7.567 | 7.639 | 7.712 | 32 | 7.782 | 7.782 | 7.924 |
| 7.259 | 7.326 | 7.395 | 31 | 7.461 | 7.528 | 7.596 |
| 6.952 | 7.015 | 7.080 | 30 | 7.142 | 7.205 | 7.268 |
| 6.645 | 6.706 | 6.766 | 29 | 6.824 | 6.885 | 6.944 |
| 6.341 | 6.397 | 6.454 | 28 | 6.509 | 6.567 | 6.622 |
| 6.038 | 6.091 | 6.145 | 27 | 6.195 | 6.250 | 6.302 |
| 5.736 | 5.786 | 5.839 | 26 | 5.885 | 5.938 | 5.988 |
| 5.439 | 5.485 | 5.535 | 25 | 5.578 | 5.628 | 5.675 |
| 5.144 | 5.188 | 5.232 | 24 | 5.274 | 5.320 | 5.364 |
| 4.852 | 4.892 | 4.934 | 23 | 4.975 | 5.014 | 5.056 |
| 4.563 | 4.599 | 4.639 | 22 | 4.677 | 4.715 | 4.753 |
| 4.278 | 4.311 | 4.374 | 21 | 4.383 | 4.418 | 4.453 |
| 3.997 | 4.025 | 4.062 | 20 | 4.094 | 4.127 | 4.161 |
| 3.719 | 3.748 | 3.781 | 19 | 3.809 | 3.839 | 3.871 |
| 3.446 | 3.474 | 3.501 | 18 | 3.529 | 3.556 | 3.585 |
| 3.179 | 3.204 | 3.229 | 17 | 3.255 | 3.280 | 3.305 |
| 2.917 | 2.938 | 2.962 | 16 | 2.985 | 3.008 | 3.032 |
| 2.658 | 2.681 | 2.702 | 15 | 2.723 | 2.744 | 2.764 |
| 2.408 | 2.429 | 2.447 | 14 | 2.467 | 2.485 | 2.503 |
| 2.167 | 1.184 | 2.200 | 13 | 2.216 | 2.234 | 2.250 |
| 1.932 | 1.946 | 1.960 | 12 | 1.978 | 1.990 | 2.003 |
| 1.703 | 1.716 | 1.727 | 11 | 1.742 | 1.753 | 1.767 |
| 1.483 | 1.494 | 1.505 | 10 | 1.515 | 1.527 | 1.538 |
| 1.272 | 1.281 | 1.291 | 9 | 1.300 | 1.309 | 1.318 |
| 1.071 | 1.079 | 1.086 | 8 | 1.095 | 1.102 | 1.110 |
| .880 | .887 | .893 | 7 | .899 | .906 | .912 |
| .701 | .707 | .712 | 6 | .717 | .722 | .727 |
| .536 | .540 | .544 | 5 | .548 | .551 | .555 |
| .386 | .388 | .391 | 4 | .393 | .396 | .399 |
| .252 | .253 | .254 | 3 | .256 | .259 | .260 |
| .138 | .138 | .139 | 2 | .140 | .141 | .142 |
| .048 | .049 | .049 | 1 | .050 | .050 | .050 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tanks in Inches.

| 78 Inches in Diameter | 79 Inches in Diameter | 80 Inches in Diameter | Depth Inches | 81 inches in Diameter | 82 Inches in Diameter | 83 Inches in Diameter |
|---|---|---|---|---|---|---|
| ........... | ........... | ........... | 41½ | ........... | ........... | 11.711 |
| ........... | ........... | ........... | 41 | ........... | 11.431 | 11.531 |
| ........... | ........... | ........... | 40½ | 11.154 | ........... | ........... |
| ........... | ........... | 10.880 | 40 | 10.978 | 11.075 | 11.172 |
| ........... | 10.610 | ........... | 39½ | ........... | ........... | ........... |
| 10.343 | 10.439 | 10.533 | 39 | 10.627 | 10.720 | 10.814 |
| 10.000 | 10.097 | 10.187 | 38 | 10.277 | 10.365 | 10.456 |
| 9.666 | 9.756 | 9.841 | 37 | 9.927 | 10.012 | 10.098 |
| 9.329 | 9.416 | 9.496 | 36 | 9.578 | 9.659 | 9.741 |
| 8.994 | 9.076 | 9.151 | 35 | 9.231 | 9.307 | 9.385 |
| 8.659 | 8.737 | 8.809 | 24 | 5.532 | 5.574 | 5.615 |
| 8.325 | 8.398 | 8.468 | 33 | 8.538 | 8.608 | 8.679 |
| 7.992 | 8.060 | 8.128 | 32 | 8.194 | 8.260 | 8.328 |
| 7.660 | 7.724 | 7.789 | 31 | 7.854 | 7.916 | 7.980 |
| 7.330 | 7.391 | 7.454 | 30 | 7.514 | 7.575 | 7.633 |
| 7.001 | 7.059 | 7.120 | 29 | 7.176 | 7.234 | 7.286 |
| 6.676 | 6.734 | 6.788 | 28 | 6.842 | 6.893 | 6.947 |
| 6.354 | 6.407 | 6.458 | 27 | 6.508 | 6.557 | 6.610 |
| 6.035 | 6.085 | 6.132 | 26 | 6.181 | 6.228 | 6.274 |
| 5.719 | 5.764 | 5.809 | 25 | 5.583 | 5.899 | 5.943 |
| 5.406 | 5.449 | 5.490 | 24 | 5.532 | 5.574 | 5.615 |
| 5.096 | 5.138 | 5.175 | 23 | 5.212 | 5.252 | 5.291 |
| 4.791 | 4.829 | 4.864 | 22 | 4.900 | 4.933 | 4.970 |
| 4.487 | 4.523 | 4.557 | 21 | 4.592 | 4.624 | 4.657 |
| 4.189 | 4.224 | 4.254 | 20 | 4.286 | 4.316 | 4.436 |
| 3.897 | 3.928 | 3.956 | 19 | 3.987 | 4.013 | 4.043 |
| 3.610 | 3.637 | 3.665 | 18 | 3.691 | 3.717 | 3.742 |
| 3.329 | 3.355 | 3.377 | 17 | 3.403 | 3.426 | 3.450 |
| 3.053 | 3.076 | 3.098 | 16 | 3.120 | 3.141 | 3.164 |
| 2.784 | 2.804 | 2.825 | 15 | 2.846 | 2.863 | 2.883 |
| 2.522 | 2.540 | 2.558 | 14 | 2.576 | 2.592 | 2.612 |
| 2.267 | 2.282 | 2.299 | 13 | 2.315 | 2.329 | 2.345 |
| 2.019 | 2.033 | 2.047 | 12 | 2.062 | 2.074 | 2.089 |
| 1.779 | 1.791 | 1.804 | 11 | 1.816 | 1.827 | 1.840 |
| 1.548 | 1.560 | 1.570 | 10 | 1.582 | 1.591 | 1.606 |
| 1.328 | 1.336 | 1.345 | 9 | 1.355 | 1.365 | 1.372 |
| 1.118 | 1.126 | 1.132 | 8 | 1.141 | 1.148 | 1.156 |
| .919 | .925 | .931 | 7 | .937 | .943 | .950 |
| .731 | .736 | .742 | 5 | .569 | .574 | .576 |
| .559 | .563 | .565 | 6 | .746 | .752 | .757 |
| .401 | .404 | .407 | 4 | .409 | .412 | .415 |
| .261 | .264 | .265 | 3 | .267 | .269 | .269 |
| .143 | .143 | .145 | 2 | .146 | .147 | .148 |
| .051 | .051 | .051 | 1 | .052 | .052 | .053 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tanks in Inches.

| 84 inches in Diameter | 85 inches in Diameter | 86 inches in Diameter | Depth Inches | 87 inches in Diameter | 88 inches in Diameter | 89 inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 44½ | ............ | ............ | 13.466 |
| ............ | ............ | ............ | 44 | ............ | 13.165 | ............ |
| ............ | ............ | ............ | 43½ | 12.867 | ............ | ............ |
| ............ | ............ | 12.573 | 43 | 12.679 | 12.783 | 12.887 |
| ............ | 12.283 | ............ | 42½ | ............ | ............ | ............ |
| 11.995 | 12.099 | 12.201 | 42 | 12.303 | 12.401 | 12.501 |
| 11.632 | 11.731 | 11.829 | 41 | 11.927 | 12.019 | 12.116 |
| 11.269 | 11.363 | 11.457 | 40 | 11.552 | 11.638 | 11.734 |
| 10.903 | 10.997 | 11.086 | 39 | 11.177 | 11.261 | 11.352 |
| 10.544 | 10.632 | 10.716 | 38 | 10.802 | 10.884 | 10.970 |
| 10.183 | 10.267 | 10.347 | 37 | 10.430 | 10.508 | 10.589 |
| 9.822 | 9.903 | 9.979 | 36 | 10.058 | 10.132 | 10.209 |
| 9.462 | 9.540 | 9.611 | 35 | 9.687 | 9.759 | 9.832 |
| 9.104 | 9.177 | 9.245 | 34 | 9.318 | 9.387 | 9.458 |
| 8.747 | 8.816 | 8.883 | 33 | 8.951 | 9.018 | 9.085 |
| 8.392 | 8.459 | 8.523 | 32 | 8.587 | 8.651 | 8.713 |
| 8.040 | 8.105 | 8.164 | 31 | 8.226 | 8.287 | 8.345 |
| 7.690 | 7.751 | 7.807 | 30 | 7.865 | 7.925 | 7.978 |
| 7.344 | 7.401 | 7.454 | 29 | 7.509 | 7.566 | 7.617 |
| 7.000 | 7.054 | 7.104 | 28 | 7.156 | 7.210 | 7.258 |
| 6.658 | 6.710 | 6.756 | 27 | 6.805 | 6.856 | 6.901 |
| 6.320 | 6.369 | 6.413 | 26 | 6.458 | 6.504 | 6 549 |
| 5.983 | 6.030 | 6.074 | 25 | 6.118 | 6.158 | 6.201 |
| 5.656 | 5.699 | 5.738 | 24 | 5.773 | 5.816 | 5.858 |
| 5.330 | 5.368 | 5.404 | 23 | 5.445 | 5.482 | 5.516 |
| 5.007 | 5.043 | 5.078 | 22 | 5.114 | 5.150 | 5.182 |
| 4.690 | 4.724 | 4.756 | 21 | 4.790 | 4.821 | 4.855 |
| 4.378 | 4.410 | 4.440 | 20 | 4.469 | 4.499 | 4.528 |
| 4.071 | 4.098 | 4.126 | 19 | 4.155 | 4.181 | 4.211 |
| 3.770 | 3.796 | 3.821 | 18 | 3.847 | 3.872 | 3.896 |
| 3.475 | 3.497 | 3.522 | 17 | 3.544 | 3.576 | 3.590 |
| 3.186 | 3.206 | 3.227 | 16 | 3.249 | 3.269 | 3.291 |
| 2.904 | 2.924 | 2.941 | 15 | 2.961 | 2.980 | 2.999 |
| 2.629 | 2.646 | 2.663 | 14 | 2.679 | 2.699 | 2.714 |
| 2.362 | 2.378 | 2.393 | 13 | 2.406 | 2.421 | 2.439 |
| 2.104 | 2.116 | 2.129 | 12 | 2.142 | 2.154 | 2.169 |
| 1.853 | 1.865 | 1.876 | 11 | 1.888 | 1.900 | 1.200 |
| 1.613 | 1.621 | 1.633 | 10 | 1.641 | 1.656 | 1.663 |
| 1.383 | 1.391 | 1.400 | 9 | 1.407 | 1.416 | 1.425 |
| 1.162 | 1.169 | 1.176 | 8 | 1.185 | 1.190 | 1.200 |
| .954 | .962 | .967 | 7 | .973 | .979 | .983 |
| .760 | .765 | .770 | 6 | .776 | .778 | .784 |
| .580 | .585 | .587 | 5 | .592 | .595 | .598 |
| .417 | .420 | .422 | 4 | .429 | .429 | .430 |
| .272 | .274 | .275 | 3 | .278 | .279 | .280 |
| .148 | .149 | .151 | 2 | .151 | .153 | .154 |
| .053 | .053 | .053 | 1 | .054 | .055 | .055 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tanks in Inches.

| 90 Inches in Diameter | 91 Inches in Diameter | 92 Inches in Diameter | Depth Inches | 93 Inches in Diameter | 94 Inches in Diameter | 95 Inches in Diameter |
|---|---|---|---|---|---|---|
| ............ | ............ | ............ | 47½ | ............ | ............ | 15.342 |
| ............ | ............ | ............ | 47 | ............ | 15.021 | 15.136 |
| ............ | ............ | ............ | 46½ | 14.703 | ............ | ............ |
| ............ | ............ | 14.388 | 46 | 14.501 | 14.612 | 14.726 |
| ............ | 14.078 | ............ | 45½ | ............ | ............ | ............ |
| 13.770 | 13.880 | 13.988 | 45 | 14.098 | 14.207 | 14.316 |
| 13.378 | 13.487 | 13.590 | 44 | 13.693 | 13.802 | 13.905 |
| 12.987 | 13.094 | 13.194 | 43 | 13.296 | 13.397 | 13.495 |
| 12.597 | 12.701 | 12.798 | 42 | 12.896 | 12.993 | 13.086 |
| 12.209 | 12.308 | 12.403 | 41 | 12.497 | 12.590 | 12.679 |
| 11.822 | 11.915 | 12.008 | 40 | 12.098 | 12.187 | 12.273 |
| 11.436 | 11.525 | 11.613 | 39 | 11.699 | 11.785 | 11.867 |
| 11.051 | 11.137 | 11.218 | 38 | 11.301 | 11.384 | 11.463 |
| 10.667 | 10.750 | 10.826 | 37 | 10.906 | 10.983 | 11.061 |
| 10.284 | 10.363 | 10.438 | 36 | 10.513 | 10.587 | 10.662 |
| 9.903 | 9.977 | 10.050 | 35 | 10.123 | 10.193 | 10.265 |
| 9.524 | 9.596 | 9.665 | 34 | 9.733 | 9.800 | 9.870 |
| 9.184 | 9.216 | 9.281 | 33 | 9.344 | 9.410 | 9.476 |
| 8.773 | 8.837 | 8.900 | 32 | 8.962 | 9.024 | 9.084 |
| 8.403 | 8.463 | 8.523 | 31 | 8.580 | 8.639 | 8.697 |
| 8.035 | 8.093 | 8.149 | 30 | 8.200 | 8.257 | 8.313 |
| 7.670 | 7.724 | 7.777 | 29 | 7.827 | 7.880 | 7.932 |
| 7.308 | 7.358 | 7.409 | 28 | 7.456 | 7.506 | 7.553 |
| 6.948 | 6.996 | 7.046 | 27 | 7.089 | 7.138 | 7.182 |
| 6.593 | 6.638 | 6.687 | 26 | 6.727 | 6.771 | 6.812 |
| 6.242 | 6.283 | 6.331 | 25 | 6.367 | 6.407 | 6.450 |
| 5.894 | 5.934 | 5.976 | 24 | 6.013 | 6.052 | 6.090 |
| 5.552 | 5.588 | 5.626 | 23 | 5.662 | 5.700 | 5.734 |
| 5.215 | 5.248 | 5.284 | 22 | 5.320 | 5.352 | 5.386 |
| 4.883 | 4.916 | 4.948 | 21 | 4.979 | 5.010 | 5.042 |
| 4.656 | 4.587 | 4.617 | 20 | 4.647 | 4.673 | 4.701 |
| 4.235 | 4.264 | 4.292 | 19 | 4.317 | 4.343 | 4.368 |
| 3.921 | 3.946 | 3.972 | 18 | 3.996 | 4.021 | 4.045 |
| 3.611 | 3.635 | 3.657 | 17 | 3.681 | 3.703 | 3.727 |
| 3.309 | 3.331 | 3.353 | 16 | 3.375 | 3.393 | 3.414 |
| 3.014 | 3.035 | 3.056 | 15 | 3.073 | 3.091 | 3.109 |
| 2.729 | 2.747 | 2.763 | 14 | 2.781 | 2.796 | 2.814 |
| 2.452 | 2.468 | 2.480 | 13 | 2.497 | 2.510 | 2.524 |
| 2.183 | 2.196 | 2.210 | 12 | 2.222 | 2.232 | 2.248 |
| 1.922 | 1.934 | 1.946 | 11 | 1.957 | 1.966 | 1.981 |
| 1.673 | 1.682 | 1.696 | 10 | 1.703 | 1.714 | 1.723 |
| 1.433 | 1.443 | 1.455 | 9 | 1.459 | 1.469 | 1.474 |
| 1.204 | 1.214 | 1.216 | 8 | 1.226 | 1.232 | 1.240 |
| .989 | .995 | 1.000 | 7 | 1.007 | 1.010 | 1.019 |
| .787 | .793 | .799 | 6 | .803 | .807 | .812 |
| .601 | .605 | .608 | 5 | .613 | .616 | .618 |
| .432 | .435 | .440 | 4 | .440 | .445 | .445 |
| .281 | .284 | .290 | 3 | .290 | .291 | .292 |
| .154 | .155 | .156 | 2 | .157 | .158 | .160 |
| .055 | .055 | .056 | 1 | .056 | .056 | .056 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tanks in Inches.

| 96 Inches in Diameter | Depth Inches | 97 Inches in Diameter | 96 Inches in Diameter | Depth Inches | 97 Inches in Diameter |
|---|---|---|---|---|---|
| ............... | 48½ | 15.995 | 6.128 | 24 | 6.163 |
| 15.638 | 48 | 15.785 | 5.770 | 23 | 5.803 |
| 15.248 | 47 | 15.365 | 5.416 | 22 | 5.450 |
| 14.828 | 46 | 14.945 | 5.066 | 21 | 5.101 |
| 14.410 | 45 | 14.525 | 4.726 | 20 | 4.757 |
| 13.992 | 44 | 14.108 | 4.394 | 19 | 4.421 |
| 13.574 | 43 | 13.692 | 4.068 | 18 | 4.092 |
| 13.158 | 42 | 13.276 | 3.752 | 17 | 3.770 |
| 12.744 | 41 | 12.860 | 3.444 | 16 | 3.455 |
| 12.335 | 40 | 12.446 | 3.139 | 15 | 3.145 |
| 11.930 | 39 | 12.033 | 2.838 | 14 | 2.844 |
| 11.524 | 38 | 11.622 | 2.546 | 13 | 2.554 |
| 11.119 | 37 | 11.214 | 2.260 | 12 | 2.273 |
| 10.716 | 36 | 10.807 | 1.990 | 11 | 2.001 |
| 10.315 | 35 | 10.400 | 1.728 | 10 | 1.742 |
| 9.915 | 34 | 9.997 | 1.480 | 9 | 1.492 |
| 9.518 | 33 | 9.599 | 1.240 | 8 | 1.254 |
| 9.124 | 32 | 9.204 | 1.016 | 7 | 1.032 |
| 8.736 | 31 | 8.810 | .804 | 6 | .821 |
| 8.352 | 30 | 8.420 | .620 | 5 | .625 |
| 7.974 | 29 | 8.035 | .447 | 4 | .448 |
| 7.600 | 28 | 7.654 | .292 | 3 | .293 |
| 7.230 | 27 | 7.274 | .160 | 2 | .160 |
| 6.862 | 26 | 6.897 | .057 | 1 | .057 |
| 6.494 | 25 | 6.526 | | | |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tanks in Inches.

| 98 Inches in Diameter | Depth Inches | 99 Inches in Diameter | 98 Inches in Diameter | Depth Inches | 99 Inches in Diameter |
|---|---|---|---|---|---|
| ...... | 49½ | 166.662 | 6.569 | 25 | 6.607 |
| 16.327 | 49 | 16.446 | 6.203 | 24 | 6.239 |
| 15.898 | 48 | 16.016 | 5.841 | 23 | 5.874 |
| 15.473 | 47 | 15.587 | 5.484 | 22 | 5.514 |
| 15.049 | 46 | 15.159 | 5.131 | 21 | 5.160 |
| 14.626 | 45 | 14.732 | 4.786 | 20 | 4.814 |
| 14.205 | 44 | 14.305 | 4.449 | 19 | 4.472 |
| 13.784 | 43 | 13.880 | 4.116 | 18 | 4.138 |
| 13.363 | 42 | 13.458 | 3.792 | 17 | 3.811 |
| 12.944 | 41 | 13.036 | 3.472 | 16 | 3.491 |
| 12.527 | 40 | 12.615 | 3.160 | 15 | 3.181 |
| 12.111 | 39 | 12.197 | 2.856 | 14 | 2.878 |
| 11.698 | 38 | 11.780 | 2.565 | 13 | 2.583 |
| 11.287 | 37 | 11.365 | 2.282 | 12 | 2.298 |
| 10.877 | 36 | 10.952 | 2.016 | 11 | 2.025 |
| 10.468 | 35 | 10.539 | 1.754 | 10 | 1.759 |
| 10.063 | 34 | 10.128 | 1.501 | 9 | 1.508 |
| 9.661 | 33 | 9.723 | 1.260 | 8 | 1.266 |
| 9.263 | 32 | 9.322 | 1.035 | 7 | 1.040 |
| 8.867 | 31 | 8.921 | .823 | 6 | .828 |
| 8.473 | 30 | 8.526 | .628 | 5 | .633 |
| 8.085 | 29 | 8.136 | .453 | 4 | .453 |
| 7.700 | 28 | 7.747 | .295 | 3 | .297 |
| 7.318 | 27 | 7.362 | .162 | 2 | .162 |
| 6.940 | 26 | 6.982 | .058 | 1 | .058 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tank in Inches.

| 100 Inches in Diameter | Depth Inches | 101 Inches in Diameter | 100 Inches in Diameter | Depth Inches | 101 Inches in Diameter |
|---|---|---|---|---|---|
| ............... | 50½ | 17.342 | 6.647 | 25 | 6.685 |
| 17.000 | 50 | 17.122 | 6.274 | 24 | 6.311 |
| 16.565 | 49 | 16.683 | 5.908 | 23 | 5.942 |
| 16.132 | 48 | 16.247 | 5.546 | 22 | 5.579 |
| 15.699 | 47 | 15.812 | 5.190 | 21 | 5.221 |
| 15.267 | 46 | 15.377 | 4.841 | 20 | 4.868 |
| 14.837 | 45 | 14.942 | 4.498 | 19 | 4.523 |
| 14.407 | 44 | 14.507 | 4.162 | 18 | 4.185 |
| 13.978 | 43 | 14.073 | 3.833 | 17 | 3.855 |
| 13.551 | 42 | 13.642 | 3.511 | 16 | 3.531 |
| 13.125 | 41 | 13.213 | 3.198 | 15 | 3.215 |
| 12.700 | 40 | 12.784 | 2.893 | 14 | 2.908 |
| 12.277 | 39 | 12.356 | 2.597 | 13 | 2.612 |
| 11.855 | 38 | 11.931 | 2.311 | 12 | 2.324 |
| 11.436 | 37 | 11.508 | 2.035 | 11 | 2.041 |
| 11.020 | 36 | 11.090 | 1.769 | 10 | 1.779 |
| 10.605 | 35 | 10.672 | 1.516 | 9 | 1.524 |
| 10.194 | 34 | 10.257 | 1.274 | 8 | 1.282 |
| 9.785 | 33 | 9.846 | 1.046 | 7 | 1.053 |
| 9.379 | 32 | 9.437 | .833 | 6 | .838 |
| 8.977 | 31 | 9.032 | .636 | 5 | .640 |
| 8.578 | 30 | 8.630 | .456 | 4 | .458 |
| 8.184 | 29 | 8.233 | .297 | 3 | .298 |
| 7.793 | 28 | 7.840 | .162 | 2 | .162 |
| 7.407 | 27 | 7.450 | .058 | 1 | .058 |
| 7.024 | 26 | 7.065 | | | |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tank in Inches.

| 102 Inches in Diameter | Depth Inches | 103 Inches in Diameter | 102 Inches in Diameter | Depth Inches | 103 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 51½ | 18.033 | 7.108 | 26 | 7.148 |
| 17.687 | 51 | 17.811 | 6.722 | 25 | 6.764 |
| 17.246 | 50 | 17.364 | 6.340 | 24 | 6.387 |
| 16.805 | 49 | 16.918 | 5.972 | 23 | 6.010 |
| 16.364 | 48 | 16.473 | 5.608 | 22 | 5.644 |
| 15.924 | 47 | 16.030 | 5.251 | 21 | 5.281 |
| 15.485 | 46 | 15.587 | 4.895 | 20 | 4.924 |
| 15.047 | 45 | 15.144 | 4.549 | 19 | 4.576 |
| 14.609 | 44 | 14.701 | 4.208 | 18 | 4.230 |
| 14.172 | 43 | 14.259 | 3.877 | 17 | 3.896 |
| 13.738 | 42 | 13.819 | 3.554 | 16 | 3.568 |
| 13.304 | 41 | 13.384 | 3.235 | 15 | 3.250 |
| 12.871 | 40 | 12.950 | 2.916 | 14 | 2.938 |
| 12.440 | 39 | 12.516 | 2.622 | 13 | 2.639 |
| 12.011 | 38 | 12.083 | 2.333 | 12 | 2.348 |
| 11.587 | 37 | 11.655 | 2.056 | 11 | 2.069 |
| 11.163 | 36 | 11.229 | 1.787 | 10 | 1.798 |
| 10.743 | 35 | 10.805 | 1.531 | 9 | 1.542 |
| 10.325 | 34 | 10.386 | 1.278 | 8 | 1.295 |
| 9.911 | 33 | 9.968 | 1.057 | 7 | 1.064 |
| 9.498 | 32 | 9.556 | .854 | 6 | .844 |
| 9.087 | 31 | 9.147 | .642 | 5 | .646 |
| 8.680 | 30 | 8.738 | .458 | 4 | .462 |
| 8.282 | 29 | 8.331 | .300 | 3 | .301 |
| 7.884 | 28 | 7.930 | .163 | 2 | .164 |
| 7.497 | 27 | 7.537 | .058 | 1 | .059 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 104 Inches in Diameter | Depth Inches | 105 Inches in Diameter | 104 Inches in Diameter | Depth Inches | 105 Inches in Diameter |
|---|---|---|---|---|---|
| ............... | 52½ | 18.742 | 7.190 | 26 | 7.229 |
| 18.387 | 52 | 18.513 | 6.804 | 25 | 6.841 |
| 17 936 | 51 | 18.057 | 6.423 | 24 | 6.457 |
| 17.485 | 50 | 17.603 | 6.046 | 23 | 6.075 |
| 17.035 | 49 | 17.150 | 5.671 | 22 | 5.704 |
| 16.587 | 48 | 16.697 | 5.308 | 21 | 5.336 |
| 16.140 | 47 | 16.245 | 4.950 | 20 | 4.978 |
| 15.693 | 46 | 15.794 | 4.599 | 19 | 4.626 |
| 15.247 | 45 | 15.343 | 4.255 | 18 | 4.277 |
| 14.802 | 44 | 14.893 | 3.920 | 17 | 3.938 |
| 14.357 | 43 | 14.447 | 3.588 | 16 | 3.608 |
| 13.912 | 42 | 14.002 | 3.267 | 15 | 3.285 |
| 13.470 | 41 | 13.558 | 2.955 | 14 | 2.971 |
| 13.032 | 40 | 13.116 | 2.653 | 13 | 2.667 |
| 12.597 | 39 | 12.675 | 2.361 | 12 | 2.373 |
| 12.164 | 38 | 12.237 | 2.080 | 11 | 2.090 |
| 11.732 | 37 | 11.802 | 1.809 | 10 | 1.814 |
| 11.297 | 36 | 11.371 | 1.548 | 9 | 1.556 |
| 10.872 | 35 | 10.940 | 1.300 | 8 | 1.308 |
| 10.450 | 34 | 10.511 | 1.068 | 7 | 1.074 |
| 10.029 | 33 | 10.088 | .850 | 6 | .853 |
| 9.610 | 32 | 9.666 | .649 | 5 | .652 |
| 9.198 | 31 | 9.249 | .467 | 4 | .469 |
| 8.789 | 30 | 8.837 | .302 | 3 | .304 |
| 8.382 | 29 | 8.430 | .164 | 2 | .165 |
| 7.978 | 28 | 8.025 | .059 | 1 | .059 |
| 7.582 | 27 | 7.623 | | | |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 106 Inches in Diameter | Depth Inches | 107 Inches in Diameter | 106 Inches in Diameter | Depth Inches | 107 Inches in Diameter |
|---|---|---|---|---|---|
| ............... | 53½ | 19.463 | 7.668 | 27 | 7.710 |
| 19.101 | 53 | 19.230 | 7.272 | 26 | 7.312 |
| 18.639 | 52 | 18.766 | 6.877 | 25 | 6.919 |
| 18.180 | 51 | 18.303 | 6.491 | 24 | 6.526 |
| 17.723 | 50 | 17.841 | 6.111 | 23 | 6.143 |
| 17.266 | 49 | 17.381 | 5.733 | 22 | 5.767 |
| 16.810 | 48 | 16.922 | 5.366 | 21 | 5.395 |
| 16.354 | 47 | 16.463 | 5.005 | 20 | 5.029 |
| 15.898 | 46 | 16.004 | 4.648 | 19 | 4.673 |
| 15.444 | 45 | 15.545 | 4.300 | 18 | 4.323 |
| 14.991 | 44 | 15.087 | 3.960 | 17 | 3.980 |
| 14.539 | 43 | 14.629 | 3.626 | 16 | 3.643 |
| 14.089 | 42 | 14.176 | 3.302 | 15 | 3.320 |
| 13.642 | 41 | 13.724 | 2.988 | 14 | 3.001 |
| 13.196 | 40 | 13.275 | 2.680 | 13 | 2.696 |
| 12.752 | 39 | 12.828 | 2.384 | 12 | 2.398 |
| 12.310 | 38 | 12.384 | 2.101 | 11 | 2.110 |
| 11.869 | 37 | 11.943 | 1.824 | 10 | 1.834 |
| 11.434 | 36 | 11.503 | 1.564 | 9 | 1.571 |
| 11.005 | 35 | 11.069 | 1.314 | 8 | 1.320 |
| 10.576 | 34 | 10.635 | 1.077 | 7 | 1.084 |
| 10.150 | 33 | 10.205 | .858 | 6 | .862 |
| 9.725 | 32 | 9.779 | .655 | 5 | .658 |
| 9.303 | 31 | 9.354 | .470 | 4 | .473 |
| 8.888 | 30 | 8.937 | .306 | 3 | .306 |
| 8.474 | 29 | 8.523 | .166 | 2 | .167 |
| 8.069 | 28 | 8.116 | .059 | 1 | .060 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 108 Inches in Diameter | Depth Inches | 109 Inches in Diameter | 108 Inches in Diameter | Depth Inches | 109 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 54½ | 20.198 | 7.756 | 27 | 7.796 |
| 19.828 | 54 | 19.962 | 7.352 | 26 | 7.391 |
| 19.359 | 53 | 19.490 | 6.953 | 25 | 6.993 |
| 18.892 | 52 | 19.019 | 6.560 | 24 | 6.597 |
| 18.426 | 51 | 18.548 | 6.176 | 23 | 6.209 |
| 17.961 | 50 | 18.077 | 5.797 | 22 | 5.827 |
| 17.496 | 49 | 17.607 | 5.428 | 21 | 5.453 |
| 17.031 | 48 | 17.137 | 5.059 | 20 | 5.084 |
| 16.567 | 47 | 16.670 | 4.696 | 19 | 4.720 |
| 16.103 | 46 | 16.203 | 4.343 | 18 | 4.367 |
| 15.639 | 45 | 15.737 | 4.000 | 17 | 4.022 |
| 15.178 | 44 | 15.272 | 3.661 | 16 | 3.682 |
| 14.719 | 43 | 14.810 | 3.335 | 15 | 3.353 |
| 14.263 | 42 | 14.349 | 3.020 | 14 | 3.032 |
| 13.810 | 41 | 13.890 | 2.711 | 13 | 2.723 |
| 13.359 | 40 | 13.435 | 2.409 | 12 | 2.422 |
| 12.910 | 39 | 12.983 | 2.121 | 11 | 2.131 |
| 12.464 | 38 | 12.531 | 1.843 | 10 | 1.852 |
| 12.019 | 37 | 12.083 | 1.575 | 9 | 1.586 |
| 11.576 | 36 | 11.639 | 1.323 | 8 | 1.336 |
| 11.135 | 35 | 11.197 | 1.085 | 7 | 1.095 |
| 10.698 | 34 | 10.758 | .868 | 6 | .871 |
| 10.265 | 33 | 10.322 | .662 | 5 | .665 |
| 9.836 | 32 | 9.892 | .476 | 4 | .477 |
| 9.412 | 31 | 9.463 | .309 | 3 | .309 |
| 9.992 | 30 | 9.037 | .169 | 2 | .170 |
| 8.576 | 29 | 8.619 | .060 | 1 | .060 |
| 8.165 | 28 | 8.207 | | | |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 110 Inches in Diameter | Depth Inches | 111 Inches in Diameter | 110 Inches in Diameter | Depth Inches | 111 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 55½ | 20.946 | 8.244 | 28 | 8.290 |
| 20.570 | 55 | 20.703 | 7.833 | 27 | 7.878 |
| 20.093 | 54 | 20.219 | 7.428 | 26 | 7.468 |
| 19.616 | 53 | 19.738 | 7.026 | 25 | 7.063 |
| 19.140 | 52 | 19.259 | 6.628 | 24 | 6.665 |
| 18.664 | 51 | 18.781 | 6.238 | 23 | 6.274 |
| 18.188 | 50 | 18.305 | 5.856 | 22 | 5.888 |
| 17.715 | 49 | 17.829 | 5.481 | 21 | 5.509 |
| 17.244 | 48 | 17.353 | 5.116 | 20 | 5.136 |
| 16.774 | 47 | 16.877 | 4.754 | 19 | 4.771 |
| 16.304 | 46 | 16.403 | 4.396 | 18 | 4.413 |
| 15.836 | 45 | 15.932 | 4.046 | 17 | 4.059 |
| 15.368 | 44 | 15.461 | 3.704 | 16 | 3.718 |
| 14.905 | 43 | 14.992 | 3.366 | 15 | 3.385 |
| 14.444 | 42 | 14.523 | 3.036 | 14 | 3.062 |
| 13.983 | 41 | 14.064 | 2.724 | 13 | 2.748 |
| 13.524 | 40 | 13.589 | 2.428 | 12 | 2.445 |
| 13.066 | 39 | 13.130 | 2.140 | 11 | 1.153 |
| 12.608 | 38 | 12.676 | 1.864 | 10 | 1.870 |
| 12.155 | 37 | 12.223 | 1.599 | 9 | 1.600 |
| 11.704 | 36 | 11.772 | 1.347 | 8 | 1.347 |
| 11.258 | 35 | 11.323 | 1.102 | 7 | 1.106 |
| 10.816 | 34 | 10.879 | .876 | 6 | .880 |
| 10.378 | 33 | 10.437 | .671 | 5 | .671 |
| 9.944 | 32 | 10.002 | .479 | 4 | .480 |
| 9.514 | 31 | 9.570 | .310 | 3 | .312 |
| 9.087 | 30 | 9.141 | .170 | 2 | .170 |
| 8.664 | 29 | 8.714 | .060 | 1 | .061 |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 112 Inches in Diameter | Depth Inches | 113 Inches in Diameter | 112 Inches in Diameter | Depth Inches | 113 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 56½ | 21.707 | 8.338 | 28 | 8.383 |
| 21.325 | 56 | 21.461 | 7.919 | 27 | 7.962 |
| 20.837 | 55 | 20.971 | 7.507 | 26 | 7.548 |
| 20.349 | 54 | 20.481 | 7.101 | 25 | 7.139 |
| 19.863 | 53 | 19.991 | 6.703 | 24 | 6.736 |
| 19.379 | 52 | 19.504 | 6.307 | 23 | 6.339 |
| 18.897 | 51 | 19.017 | 5.916 | 22 | 5.948 |
| 18.415 | 50 | 18.530 | 5.536 | 21 | 5.560 |
| 17.936 | 49 | 18.044 | 5.163 | 20 | 5.188 |
| 17.457 | 48 | 17.559 | 4.795 | 19 | 4.817 |
| 16.980 | 47 | 17.074 | 4.434 | 18 | 4.457 |
| 16.503 | 46 | 16.590 | 4.081 | 17 | 4.101 |
| 16.028 | 45 | 16.112 | 3.738 | 16 | 3.755 |
| 15.554 | 44 | 15.638 | 3.402 | 15 | 3.419 |
| 15.080 | 43 | 15.165 | 3.077 | 14 | 3.091 |
| 14.610 | 42 | 14.692 | 2.764 | 13 | 2.772 |
| 14.141 | 41 | 14.221 | 2.457 | 12 | 2.468 |
| 13.672 | 40 | 13.751 | 2.162 | 11 | 2.171 |
| 13.210 | 39 | 13.283 | 1.881 | 10 | 1.887 |
| 12.751 | 38 | 12.821 | 1.610 | 9 | 1.615 |
| 12.292 | 37 | 12.361 | 1.350 | 8 | 1.357 |
| 11.838 | 36 | 11.904 | 1.111 | 7 | 1.113 |
| 11.388 | 35 | 11.449 | .885 | 6 | .886 |
| 10.942 | 34 | 10.999 | .674 | 5 | .675 |
| 10.497 | 33 | 10.552 | .482 | 4 | .486 |
| 10.055 | 32 | 10.108 | .314 | 3 | .317 |
| 9.620 | 31 | 9.669 | .171 | 2 | .171 |
| 9.188 | 30 | 9.235 | .031 | 1 | .062 |
| 8.761 | 29 | 8.805 | | | |

## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 114 Inches in Diameter | Depth Inches | 115 Inches in Diameter | 114 Inches in Diameter | Depth Inches | 115 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 57½ | 22.482 | 8.855 | 29 | 8.898 |
| 22.093 | 57 | 22.230 | 8.425 | 28 | 8.468 |
| 21.599 | 56 | 21.733 | 8.003 | 27 | 8.040 |
| 21.105 | 55 | 21.236 | 7.583 | 26 | 7.622 |
| 20.611 | 54 | 20.740 | 7.176 | 25 | 7.213 |
| 20.117 | 53 | 20.244 | 6.770 | 24 | 6.806 |
| 19.624 | 52 | 19.748 | 6.369 | 23 | 6.401 |
| 19.132 | 51 | 19.252 | 5.978 | 22 | 6.007 |
| 18.643 | 50 | 18.756 | 5.592 | 21 | 5.619 |
| 18.155 | 49 | 18.262 | 5.212 | 20 | 5.238 |
| 17.668 | 48 | 17.772 | 4.841 | 19 | 4.865 |
| 17.181 | 47 | 17.282 | 4.476 | 18 | 4.499 |
| 16.695 | 46 | 16.795 | 4.120 | 17 | 4.139 |
| 16.212 | 45 | 16.309 | 3.771 | 16 | 3.786 |
| 15.731 | 44 | 15.823 | 3.436 | 15 | 3.451 |
| 15.253 | 43 | 15.341 | 3.109 | 14 | 3.121 |
| 14.775 | 42 | 14.862 | 2.786 | 13 | 2.799 |
| 14.299 | 41 | 14.383 | 2.481 | 12 | 2.491 |
| 13.828 | 40 | 13.906 | 2.183 | 11 | 2.192 |
| 13.360 | 39 | 13.431 | 1.898 | 10 | 1.907 |
| 12.893 | 38 | 12.964 | 1.624 | 9 | 1.632 |
| 12.428 | 37 | 12.497 | 1.365 | 8 | 1.371 |
| 11.967 | 36 | 12.033 | 1.120 | 7 | 1.126 |
| 11.511 | 35 | 11.572 | .890 | 6 | .895 |
| 11.057 | 34 | 11.116 | .681 | 5 | .684 |
| 10.609 | 33 | 10.664 | .488 | 4 | .490 |
| 10.165 | 32 | 10.217 | .317 | 3 | .319 |
| 9.722 | 31 | 9.771 | .172 | 2 | .173 |
| 9.288 | 30 | 9.331 | .062 | 1 | .062 |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tank in Inches.

| 116 Inches in Diameter | Depth Inches | 117 Inches in Diameter | 116 Inches in Diameter | Depth Inches | 117 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 58½ | 23.271 | 8.944 | 29 | 8.988 |
| 22.875 | 58 | 23.016 | 8.513 | 28 | 8.555 |
| 22.371 | 57 | 22.506 | 8.086 | 27 | 8.125 |
| 21.868 | 56 | 21.998 | 7.663 | 26 | 7.701 |
| 21.366 | 55 | 21.493 | 7.247 | 25 | 7.282 |
| 20.865 | 54 | 20.989 | 6.838 | 24 | 6.870 |
| 20.365 | 53 | 20.485 | 6.434 | 23 | 6.460 |
| 19.866 | 52 | 19.992 | 6.036 | 22 | 6.065 |
| 19.368 | 51 | 19.479 | 5.645 | 21 | 5.675 |
| 18.870 | 50 | 18.977 | 5.262 | 20 | 5.292 |
| 18.373 | 49 | 18.476 | 4.888 | 19 | 4.913 |
| 17.877 | 48 | 17.975 | 4.519 | 18 | 4.541 |
| 17.382 | 47 | 17.478 | 4.160 | 17 | 4.179 |
| 16.888 | 46 | 16.984 | 3.813 | 16 | 3.826 |
| 16.398 | 45 | 16.491 | 3.468 | 15 | 3.483 |
| 15.911 | 44 | 15.999 | 3.136 | 14 | 3.149 |
| 15.427 | 43 | 15.510 | 2.813 | 13 | 2.828 |
| 14.944 | 42 | 15.024 | 2.502 | 12 | 2.516 |
| 14.462 | 41 | 14.540 | 2.201 | 11 | 2.215 |
| 13.981 | 40 | 14.056 | 1.914 | 10 | 1.925 |
| 13.501 | 39 | 13.578 | 1.639 | 9 | 1.645 |
| 13.023 | 38 | 13.102 | 1.376 | 8 | 1.385 |
| 12.549 | 37 | 12.632 | 1.131 | 7 | 1.136 |
| 12.079 | 36 | 12.162 | .899 | 6 | .903 |
| 11.613 | 35 | 11.698 | .686 | 5 | .689 |
| 11.152 | 34 | 11.238 | .492 | 4 | .496 |
| 10.697 | 33 | 10.778 | .320 | 3 | .321 |
| 10.250 | 32 | 10.323 | .175 | 2 | .175 |
| 9.812 | 31 | 9.872 | .062 | 1 | .063 |
| 9.377 | 30 | 9.428 | | | |

## HORIZONTAL TANKS.

Multiply Capacity in Tables by Length of Tank in Inches.

| 118 Inches in Diameter | Depth Inches | 119 Inches in Diameter | 118 Inches in Diameter | Depth Inches | 119 Inches in Diameter |
|---|---|---|---|---|---|
| .............. | 59½ | 24.074 | 9.476 | 30 | 9.524 |
| 23.671 | 59 | 23.816 | 9.031 | 29 | 9.082 |
| 23.160 | 58 | 23.301 | 8.595 | 28 | 8.643 |
| 22.649 | 57 | 22.787 | 8.165 | 27 | 8.207 |
| 22.138 | 56 | 22.273 | 7.739 | 26 | 7.779 |
| 21.627 | 55 | 21.760 | 7.319 | 25 | 7.357 |
| 21.117 | 54 | 21.247 | 6.905 | 24 | 6.940 |
| 20.609 | 53 | 20.734 | 6.496 | 23 | 6.529 |
| 20.102 | 52 | 20.221 | 6.094 | 22 | 6.127 |
| 19.597 | 51 | 19.710 | 5.702 | 21 | 5.730 |
| 19.092 | 50 | 19.203 | 5.317 | 20 | 5.342 |
| 18.587 | 49 | 18.697 | 4.937 | 19 | 4.959 |
| 18.083 | 48 | 18.191 | 4.562 | 18 | 4.587 |
| 17.582 | 47 | 17.685 | 4.197 | 17 | 4.220 |
| 17.082 | 46 | 17.182 | 3.845 | 16 | 3.867 |
| 16.584 | 45 | 16.681 | 3.501 | 15 | 3.520 |
| 16.088 | 44 | 16.180 | 3.163 | 14 | 3.180 |
| 15.595 | 43 | 15.682 | 2.841 | 13 | 2.853 |
| 15.105 | 42 | 15.188 | 2.526 | 12 | 2.535 |
| 14.620 | 41 | 14.697 | 2.223 | 11 | 2.232 |
| 14.137 | 40 | 14.209 | 1.932 | 10 | 1.938 |
| 13.654 | 39 | 13.725 | 1.655 | 9 | 1.659 |
| 13.174 | 38 | 13.245 | 1.390 | 8 | 1.396 |
| 12.698 | 37 | 12.767 | 1.141 | 7 | 1.146 |
| 12.225 | 36 | 12.291 | .909 | 6 | .910 |
| 11.758 | 35 | 11.818 | .694 | 5 | .696 |
| 11.292 | 34 | 11.350 | .497 | 4 | .498 |
| 10.832 | 33 | 10.888 | .322 | 3 | .325 |
| 10.377 | 32 | 10.429 | .175 | 2 | .178 |
| 9.924 | 31 | 9.975 | .063 | 1 | .063 |

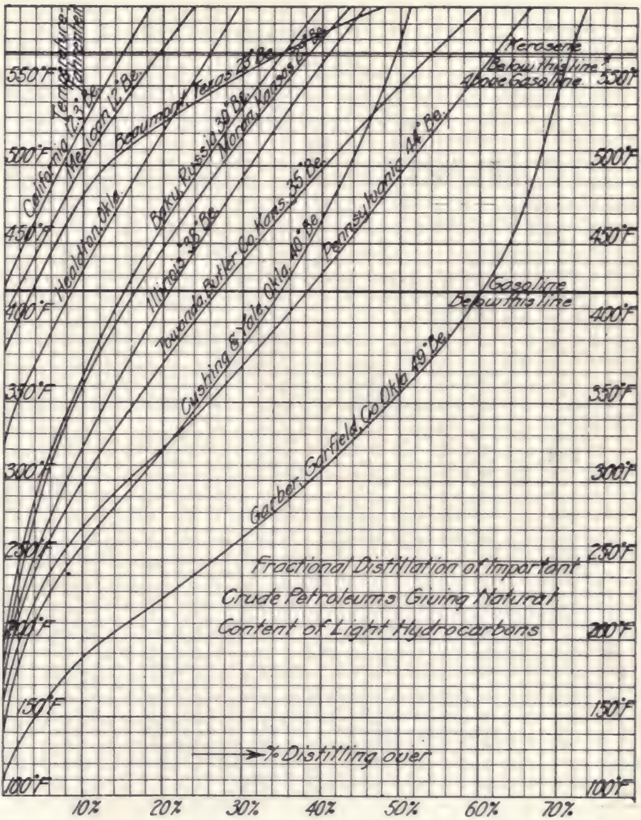
## HORIZONTAL TANKS.
Multiply Capacity in Tables by Length of Tank in Inches.

| 120 Inches in Diameter | Depth Inches | 120 Inches in Diameter | Depth Inches | 120 Inches in Diameter | Depth Inches |
|---|---|---|---|---|---|
| 24.479 | 60 | 14.287 | 40 | 5.363 | 20 |
| 23.954 | 59 | 13.797 | 39 | 4.981 | 19 |
| 23.434 | 58 | 13.314 | 38 | 4.608 | 18 |
| 22.914 | 57 | 12.833 | 37 | 4.240 | 17 |
| 22.395 | 56 | 12.354 | 36 | 3.882 | 16 |
| 21.877 | 55 | 11.881 | 35 | 3.538 | 15 |
| 21.359 | 54 | 11.411 | 34 | 3.198 | 14 |
| 20.842 | 53 | 10.944 | 33 | 2.866 | 13 |
| 20.328 | 52 | 10.483 | 32 | 2.537 | 12 |
| 19.815 | 51 | 10.024 | 31 | 2.239 | 11 |
| 19.305 | 50 | 9.567 | 30 | 1.949 | 10 |
| 18.795 | 49 | 9.124 | 29 | 1.668 | 9 |
| 18.287 | 48 | 8.683 | 28 | 1.396 | 8 |
| 17.780 | 47 | 8.244 | 27 | 1.151 | 7 |
| 17.273 | 46 | 7.816 | 26 | .915 | 6 |
| 16.767 | 45 | 7.393 | 25 | .699 | 5 |
| 16.265 | 44 | 6.976 | 24 | .501 | 4 |
| 15.768 | 43 | 6.561 | 23 | .326 | 3 |
| 15.273 | 42 | 6.153 | 22 | .178 | 2 |
| 14.779 | 41 | 5.751 | 21 | .063 | 1 |

# Content of Crude Oils

(Typical Samples.)

| Source | Specific Gravity | Natural Commercial Automobile Gasoline, % by Vol. to 410° F. | Kerosene, 410° F., 572° F., % by Vol. | Total Obtainable Gasoline, Natural and Artificial (KCTL Test), % by Vol. |
|---|---|---|---|---|
| Garber, Garfield Co., Oklahoma.. | 49.5°Be' 0.780 | 60.0% | 10.8% | 91.0% |
| Pennsylvania (Light)............ | 44.5°Be' 0.802 | 37.5% | 12.7% | 86.2% |
| Cushing, Oklahoma............... | 40.1°Be' 0.823 | 35.0% | 15.0% | 83.7% |
| Towanda, Butler Co., Kansas....... | 34.7°Be' 0.850 | 26.5% | 27.5% | 77.9% |
| Neodesha, Wilson Co., Kansas....... | 33.3°Be' 0.8[illegible]0 | 25.0% | 17.0% | 81.2% |
| Newkirk, Oklahoma............... | 40.3°Be' 0.822 | 32.5% | 24.0% | 83.1% |
| Mexico (Panuco).................. | 11.4°Be' 0.990 | 2.0% | 18.0% | 44.5% |
| California......................... | 12.3°Be' 0.984 | 0.0% | 12.3% | 50.0% |
| Texas (Beaumont)................. | 23.4°Be' 0.912 | 4.0% | 16.0% | 61.0% |
| Russia.............................. | 30.2°Be' 0.874 | 15.0% | 20.0% | ..... |
| Healdton, Oklahoma............... | 22.1°Be' 0.920 | 8.5% | 17.5% | 64.0% |
| Moran, Kansas (Allen County)...... | 30.7°Be' 0.871 | 15.0% | 17.5% | 74 5% |
| Kentucky (Wayne County)........... | 37.7°Be' 0 835 | 28.0% | 21.0% | ..... |
| Wyoming (Lander County).......... | 24.0°Be' 0.909 | 13.0% | 13.0% | ..... |
| Ranger, Texas...................... | 39.2°Be' 0.829 | 30.0% | 25.0% | 84.0% |
| Burkburnett, Texas.............. | 40.1°Be' 0 8[illegible]4 | 41.0% | 20.0% | 83.5% |
| Pine Island, Louisiana................ | 25.4°Be' 0.902 | 0.0% | 25.0% | 57.0% |
| West Virginia, Cabin Creek.......... | 48 0°Be' | 36.0% | 24.0% | 86.0% |




Diagrammatic Proximate Composition of Crude Petroleum as to Gasoline and Kerosene.

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF BURKBURNETT, TEXAS, CRUDE OIL.

Specific Gravity, 0.821; °Be′ U. S., 40.5°; °Be′ Tag, 40.9°.
Summary: 59.7°Be′ Gasoline = 40.0%; 40.5°Be′ Kerosene = 25.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 121 | ................ | ................ | ................ |
| | 179 | ................ | ................ | 0.686 = 74.8°Be′ |
| 5 | 197 | 0.686 = 74.8°Be′ | 0.686 = 74.8°Be′ | 0.693 = 72.7°Be′ |
| | 211 | | | 0.701 = 70.4°Be′ |
| 10 | 227 | 0.701 = 70.4°Be′ | 0.693 = 72.7°Be′ | 0.710 = 67.8°Be′ |
| | 238 | | | 0.720 = 65.0°Be′ |
| 15 | 253 | 0.720 = 65.0°Be′ | 0.702 = 70.1°Be′ | 0.729 = 62.6°Be′ |
| | 268 | | | 0.738 = 60.2°Be′ |
| 20 | 283 | 0.738 = 60.2°Be′ | 0.711 = 67.5°Be′ | 0.744 = 58.7°Be′ |
| | 295 | | | 0.751 = 56.9°Be′ |
| 25 | 309 | 0.751 = 56.9°Be′ | 0.719 = 65.3°Be′ | 0.756 = 55.7°Be′ |
| | 322 | | | 0.762 = 54.2°Be′ |
| 30 | 342 | 0.762 = 54.2°Be′ | 0.726 = 63.4°Be′ | 0.769 = 52.5°Be′ |
| | 358 | | | 0.776 = 50.8°Be′ |
| 35 | 375 | 0.776 = 50.8°Be′ | 0.733 = 61.6°Be′ | 0.782 = 49.4°Be′ |
| | 394 | | | 0.789 = 47.8°Be′ |
| 40 | 410 | 0.789 = 47.8°Be′ | 0.740 = 59.7°Be′ | 0.795 = 46.5°Be′ |
| | 426 | | | 0.801 = 45.2°Be′ |
| 45 | 440 | 0.801 = 45.2°Be′ | 0.747 = 57.9°Be′ | 0.807 = 43.8°Be′ |
| | 470 | | | 0.813 = 42.5°Be′ |
| 50 | 485 | 0.813 = 42.5°Be′ | 0.754 = 56.2°Be′ | 0.819 = 41.3°Be′ |
| | 508 | | | 0.825 = 40.0°Be′ |
| 55 | 529 | 0.825 = 40.0°Be′ | 0.760 = 54.7°Be′ | 0.829 = 39.2°Be′ |
| | 547 | | | 0.834 = 38.2°Be′ |
| 60 | 562 | 0.834 = 38.2°Be′ | 0.766 = 53.2°Be′ | 0.838 = 37.4°Be′ |
| | 574 | | | 0.842 = 36.6°Be′ |
| 65 | 578 | 0.842 = 36.6°Be′ | 0.772 = 51.8°Be′ | 0.846 = 35.8°Be′ |
| 70 | steam | 0.854 = 34.2°Be′ | 0.785 = 48.7°Be′ | 0.861 = 32.8°Be′ |
| 75 | " | 0.868 = 31.5°Be′ | 0.791 = 47.3°Be′ | 0.877 = 29.8°Be′ |
| 80 | " | 0.887 = 28.0°Be′ | 0.797 = 46.0°Be′ | 0.898 = 26.0°Be′ |
| 85 | " | 0.910 = 24.0°Be′ | 0.803 = 44.7°Be′ | 0.913 = 23.4°Be′ |
| 90 | residue | 0.916 = 22.9°Be′ | 0.809 = 43.4°Be′ | ...................... |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF BIXBY, OKLA., CRUDE OIL.

Specific Gravity, 0.845; °Be′ U. S., 35.7°; °Be′ Tag, 36.0°.
Summary: 60.7°Be′ Gasoline = 25.0%; 41.0°Be′ Kerosene = 20.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 121 | ................ | ................ | ................ |
| | 173 | ................ | ................ | 0.695 = 72.1°Be′ |
| 5 | 213 | 0.695 = 72.1°Be′ | 0.695 = 72.1°Be′ | 0.712 = 67.2°Be′ |
| | 253 | | | 0.729 = 62.6°Be′ |
| 10 | 274 | 0.729 = 62.6°Be′ | 0.712 = 67.2°Be′ | 0.734 = 61.2°Be′ |
| | 293 | | | 0.752 = 56.6°Be′ |
| 15 | 309 | 0.752 = 56.6°Be′ | 0.725 = 63.6°Be′ | 0.761 = 54.4°Be′ |
| | 337 | | | 0.770 = 52.2°Be′ |
| 20 | 370 | 0.770 = 52.2°Be′ | 0.736 = 60.7°Be′ | 0.778 = 50.3°Be′ |
| | 391 | | | 0.787 = 48.3°Be′ |
| 25 | 40[illegible] | 0.787 = 48.3°Be′ | 0.746 = 58.1°Be′ | 0.794 = 46.7°Be′ |
| | 437 | | | 0.802 = 44.7°Be′ |
| 30 | 447 | 0.802 = 44.9°Be′ | 0.755 = 55.9°Be′ | 0.807 = 43.8°Be′ |
| | 464 | | | 0.813 = 42.5°Be′ |
| 35 | 490 | 0.813 = 42.5°Be′ | 0.764 = 53.7°Be′ | 0.819 = 41.2°Be′ |
| | 512 | | | 0.826 = 39.8°Be′ |
| 40 | 534 | 0.826 = 39.8°Be′ | 0.771 = 52.0°Be′ | 0.830 = 38.9°Be′ |
| | 547 | | | 0.835 = 37.9°Be′ |
| 45 | 567 | 0.835 = 37.9°Be′ | 0.778 = 50.3°Be′ | 0.838 = 37.3°Be′ |
| | 580 | | | 0.842 = 36.5°Be′ |
| 50 | 600 | 0.842 = 36.5°Be′ | 0.785 = 48.7°Be′ | 0.848 = 35.3°Be′ |
| | steam | | | 0.855 = 34.0°Be′ |
| 55 | " | 0.855 = 34.0°Be′ | 0.791 = 47.3°Be′ | 0.860 = 33.0°Be′ |
| | " | | | 0.865 = 32.0°Be′ |
| 60 | " | 0.865 = 32.0°Be′ | 0.797 = 46.0°Be′ | 0.871 = 30.9°Be′ |
| | " | | | 0.878 = 29.6°Be′ |
| 65 | " | 0.878 = 29.6°Be′ | 0.803 = 44.7°Be′ | 0.884 = 28.5°Be′ |
| | " | | | 0.890 = 27.4°Be′ |
| 70 | " | 0.890 = 27.4°Be′ | 0.809 = 43.4°Be′ | 0.894 = 26.7°Be′ |
| | " | | | 0.899 = 25.9°Be′ |
| 75 | " | 0.899 = 25.9°Be′ | 0.815 = 42.1°Be′ | 0.903 = 25.2°Be′ |
| | " | | | 0.907 = 24.5°Be′ |
| 80 | " | 0.907 = 24.5°Be′ | 0.820 = 41.0°Be′ | 0.911 = 23.8°Be′ |
| | " | | | 0.915 = 23.1°Be′ |
| 85 | " | 0.915 = 23.1°Be′ | 0.827 = 39.6°Be′ | 0.919 = 22.5°Be′ |
| | " | | | 0.923 = 21.8°Be′ |
| 90 | " | 0.923 = 21.8°Be′ | 0.833 = 38.4°Be′ | ................ |
| | " | | | |
| 95-100 | residue | 0.953 = 17.0°Be′ | ................ | ................ |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF CUSHING, OKLA., CRUDE OIL.

Specific Gravity, 0.824; °Be′ U. S., 39.9°; °Be′ Tag, 40.2°.
Summary: 60.2°Be′ Gasoline = 35.0%; 42.1°Be′ Kerosene = 25.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 130 | .................. | .................. | .................. |
| | 163 | .................. | .................. | 0.685 = 75.0°Be′ |
| 5 | 179 | 0.685 = 75.0°Be′ | 0.685 = 75.0°Be′ | 0.695 = 72.1°Be′ |
| | 205 | | | 0.706 = 68.9°Be′ |
| 10 | 229 | 0.706 = 68.9°Be′ | 0.695 = 72.1°Be′ | 0.716 = 66.1°Be′ |
| | 250 | | | 0.727 = 63.1°Be′ |
| 15 | 270 | 0.727 = 63.1°Be′ | 0.706 = 68.9°Be′ | 0.736 = 60.7°Be′ |
| | 283 | | | 0.745 = 58.4°Be′ |
| 20 | 297 | 0.745 = 58.4°Be′ | 0.715 = 66.4°Be′ | 0.751 = 56.9°Be′ |
| | 316 | | | 0.757 = 55.4°Be′ |
| 25 | 327 | 0.757 = 55.4°Be′ | 0.724 = 63.9°Be′ | 0.762 = 54.2°Be′ |
| | 339 | | | 0.768 = 52.7°Be′ |
| 30 | 352 | 0.768 = 52.7°Be′ | 0.731 = 62.0°Be′ | 0.774 = 51.3°Be′ |
| | 372 | | | 0.780 = 49.9°Be′ |
| 35 | 394 | 0.780 = 49.9°Be′ | 0.738 = 60.2°Be′ | 0.786 = 48.5°Be′ |
| | 414 | | | 0.793 = 46.9°Be′ |
| 40 | 427 | 0.793 = 46.9°Be′ | 0.745 = 58.4°Be′ | 0.799 = 45.6°Be |
| | 447 | | | 0.805 = 44.2°Be′ |
| 45 | 460 | 0.805 = 44.2°Be′ | 0.751 = 56.9°Be′ | 0.810 = 43.2°Be′ |
| | 481 | | | 0.816 = 41.9°Be′ |
| 50 | 507 | 0.816 = 41.9°Be′ | 0.758 = 55.1°Be′ | 0.822 = 40.5°Be′ |
| | 523 | | | 0.826 = 39.4°Be′ |
| 55 | 542 | 0.823 = 39.4°Be′ | 0.764 = 53.7°Be′ | 0.832 = 38.5°Be′ |
| | 559 | | | 0.837 = 37.4°Be′ |
| 60 | 588 | 0.837 = 37.4°Be′ | 0.770 = 52.2°Be′ | 0.842 = 36.5°Be′ |
| | steam | | | 0.847 = 35.5°Be′ |
| 65 | " | 8.847 = 35.5°Be′ | 0.779 = 50.1°Be′ | 0.857 = 33.6°Be′ |
| | " | | | 0.867 = 31.7°Be′ |
| 70 | " | 0.867 = 31.7°Be′ | 0.785 = 48.7°Be′ | 0.875 = 30.2°Be′ |
| | " | | | 0.884 = 28.5°Be′ |
| 75 | " | 0.884 = 28.5°Be′ | 0.792 = 47.1°Be′ | 0.890 = 27.4°Be′ |
| | " | | | 0.896 = 26.4°Be′ |
| 80 | " | 0.896 = 26.4°Be′ | 0.798 = 45.8°Be′ | 0.907 = 24.5°Be′ |
| | " | | | 0.909 = 24.1°Be′ |
| 85 | " | 0.909 = 24.1°Be′ | 0.805 = 44.2°Be′ | 0.916 = 22.9°Be′ |
| | " | | | 0.924 = 21.6°Be′ |
| 90 | " | 0.924 = 21.6°Be′ | 0.811 = 42.9°Be′ | 0.930 = 20.7°Be′ |
| | " | | | .................. |
| 95-100 | residue | 0.940 = 19.0°Be′ | .................. | .................. |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF PINE ISLAND. NO. LOUISIANA, CRUDE OIL.

Specific Gravity, 0.902; °Be′ U. S., 25.2°; °Be′ Tag, 25.4°Be′.
Summary: Gasoline = none; 31.0° Kerosene = 25.0% (Naphthene base oil)

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream | |
|---|---|---|---|---|---|
| 0 | 365 | ............ | ............ | ............ | ............ |
| 5 | 471 | 0.839 = 37.2°Be′ | 0.839 = 37.2°Be′ | 0.849 = 35.1°Be′ | ............ |
| 10 | 500 | 0.860 = 33.0°Be′ | 0.849 = 35.1°Be′ | 0.864 = 32.2°Be′ | ............ |
| 15 | 530 | 0.869 = 31.3°Be′ | 0.856 = 33.8°Be′ | 0.872 = 30.7°Be′ | ............ |
| 20 | 549 | 0.876 = 30.0°Be′ | 0.861 = 32.8°Be′ | 0.878 = 29.6°Be′ | ............ |
| 25 | 564 | 0.880 = 29.3°Be′ | 0.865 = 32.0°Be′ | 0.881 = 29.1°Be′ | ............ |
| 30 | 589 | 0.883 = 28.8°Be′ | 0.867 = 31.7°Be′ | 0.886 = 28.2°Be′ | ............ |
| 35 | steam | 0.889 = 27.7°Be′ | 0.870 = 31.1°Be′ | 0.890 = 27.4°Be′ | Viscosity |
| 40 | " | 0.892 = 27.1°Be′ | 0.873 = 30.5°Be′ | 0.893 = 26.9°Be′ | 66 |
| 45 | " | 0.894 = 26.8°Be′ | 0.875 = 30.2°Be′ | 0.894 = 26.7°Be′ | 80 |
| 50 | " | 0.895 = 26.6°Be′ | 0.877 = 29.8°Be′ | 0.895 = 26.6°Be′ | 100 |
| 55 | " | 0.896 = 26.4°Be′ | 0.879 = 29.4°Be′ | 0.896 = 26.4°Be′ | 152 |
| 60 | " | 0.897 = 26.2°Be′ | 0.880 = 29.3°Be′ | 0.897 = 26.2°Be′ | 210 |
| 65 | " | 0.897 = 26.2°Be′ | 0.880 = 29.3°Be′ | 0.897 = 26.2°Be′ | 270 |
| 70 | " | 0.897 = 26.2°Be′ | 0.880 = 29.3°Be′ | 0.897 = 26.2°Be′ | 625 |
| 75 | " | 0.897 = 26.2°Be′ | 0.880 = 29.3°Be′ | 0.898 = 26.0°Be′ | 580 |
| 80 | " | 0.899 = 25.9°Be′ | 0.885 = 28.3°Be′ | 0.899 = 25.9°Be′ | 620 |
| 85 | " | 0.900 = 25.7°Be′ | 0.885 = 28.3°Be′ | 0.901 = 25.5°Be′ | 654 |
| 90 | " | 0.902 = 25.4°Be′ | 0.886 = 28.2°Be′ | ............ | waxy |
| | | | | | waxy |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF BILLINGS, OKLA., CRUDE OIL.

Specific Gravity, 0.812; °Be′ U. S. 42.4°; °Be′ Tag 42.8°.
Summary: 60.5°Be′ Gasoline = 40.0%; 41.0°Be′ Kerosene = 25.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 116 | ............ | ............ | ............ |
| | 169 | ............ | ............ | 0.679 = 76.9°Be′ |
| 5 | 191 | 0.679 = 76.9°Be′ | 0.679 = 76.9°Be′ | 0.689 = 73.8°Be′ |
| | 207 | | | 0.700 = 70.6°Be′ |
| 10 | 223 | 0.700 = 70.6°Be′ | 0.689 = 73.8°Be′ | 0.710 = 67.8°Be′ |
| | 235 | | | 0.720 = 65.0°Be′ |
| 15 | 252 | 0.720 = 65.0°Be′ | 0.699 = 70.9°Be′ | 0.728 = 62.8°Be′ |
| | 264 | | | 0.736 = 60.7°Be′ |
| 20 | 277 | 0.736 = 60.7°Be′ | 0.708 = 68.3°Be′ | 0.742 = 59.2°Be′ |
| | 286 | | | 0.748 = 57.6°Be′ |
| 25 | 303 | 0.748 = 57.6°Be′ | 0.716 = 66.1°Be′ | 0.753 = 56.4°Be′ |
| | 317 | | | 0.761 = 54.4°Be′ |
| 30 | 337 | 0.761 = 54.4°Be′ | 0.724 = 63.9°Be′ | 0.767 = 52.9°Be′ |
| | 353 | | | 0.774 = 51.3°Be′ |
| 35 | 367 | 0.774 = 51.3°Be′ | 0.731 = 62.0°Be′ | 0.779 = 50.1°Be′ |
| | 381 | | | 0.785 = 48.7°Be′ |
| 40 | 396 | 0.785 = 48.7°Be′ | 0.737 = 60.5°Be′ | 0.790 = 47.6°Be′ |
| | 413 | | | 0.795 = 46.3°Be′ |
| 45 | 431 | 0.795 = 46.3°Be′ | 0.744 = 58.7°Be′ | 0.801 = 45.1°Be′ |
| | 456 | | | 0.808 = 43.6°Be′ |
| 50 | 482 | 0.808 = 43.6°Be′ | 0.750 = 57.1°Be′ | 0.814 = 42.3°Be′ |
| | 500 | | | 0.820 = 41.0°Be′ |
| 55 | 513 | 0.820 = 41.0°Be′ | 0.756 = 55.6°Be′ | 0.825 = 40.0°Be′ |
| | 530 | | | 0.830 = 38.9°Be′ |
| 60 | 550 | 0.830 = 38.9°Be′ | 0.763 = 53.9°Be′ | 0.835 = 37.9°Be′ |
| | 577 | | | 0.840 = 36.9°Be′ |
| 65 | 593 | 0.840 = 36.9°Be′ | 0.768 = 52.7°Be′ | 0.843 = 36.3°Be′ |
| | steam | | | 0.847 = 35.5°Be′ |
| 70 | " | 0.847 = 35.5°Be′ | 0.774 = 51.3°Be′ | 0.855 = 34.0°Be′ |
| | " | | | 0.864 = 32.3°Be′ |
| 75 | " | 0.864 = 32.3°Be′ | 0.780 = 49.9°Be′ | 0.870 = 31.1°Be′ |
| | " | | | 0.878 = 29.6°Be′ |
| 80 | " | 0.878 = 29.6°Be′ | 0.786 = 48.5°Be′ | 0.886 = 28.2°Be′ |
| 85 | " | 0.893 = 27.0°Be′ | 0.792 = 47.2°Be′ | 0.900 = 25.7°Be′ |
| 90 | " | 0.906 = 24.7°Be′ | 0.798 = 45.8°Be′ | 0.918 = 22.6°Be′ |
| 95-100 | residue | 0.930 = 20.7°Be′ | ............ | ............ |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF GARBER, OKLA., CRUDE OIL.

Specific Gravity, 0.780; °Be′ U. S. 49.5°; °Be′ Tag 49.9°.
Sulphur = 0.05%.
Summary: 59.2°Be′ Gasoline = 55.0%; 40.5°Be′ Kerosene = 20.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream | Olefins % |
|---|---|---|---|---|---|
| 0 | 110 | ............... | ............... | ............... | 1.0 |
| 5 | | ............... | ............... | 0.670 = 79.7°Be′ | |
| 10 | 188 | 0.675 = 78.1°Be′ | 0.675 = 78.1°Be′ | 0.694 = 72.4°Be′ | 1.0 |
| 15 | | | 0.684 = 75.3°Be′ | 0.712 = 67.2°Be′ | |
| 20 | 226 | 0.712 = 67.2°Be′ | 0.694 = 72.4°Be′ | 0.726 = 63.4°Be′ | 1.0 |
| 25 | | | 0.701 = 70.3°Be′ | 0.739 = 59.9°Be′ | |
| 30 | 264 | 0.739 = 59.9°Be′ | 0.709 = 68.0°Be′ | 0.748 = 57.6°Be′ | 1.2 |
| 35 | | | 0.715 = 66.4°Be′ | 0.757 = 55.4°Be′ | |
| 40 | 322 | 0.757 = 55.4°Be′ | 0.721 = 64.7°Be′ | 0.769 = 52.5°Be′ | 1.4 |
| 45 | 350 | | 0.727 = 63.1°Be′ | 0.781 = 49.6°Be′ | |
| 50 | 380 | 0.781 = 49.6°Be′ | 0.733 = 61.5°Be′ | 0.793 = 46.9°Be′ | 1.5 |
| 55 | 400 | 0.793 = 47.0°Be′ | 0.742 = 59.2°Be′ | 0.806 = 44.0°Be′ | |
| 60 | 420 | 0.806 = 44.0°Be′ | 0.745 = 58.4°Be′ | 0.821 = 40.8°Be′ | 1.7 |
| 65 | 435 | 0.818 = 41.5°Be′ | 0.751 = 56.9°Be′ | 0.830 = 38.9°Be′ | |
| 70 | 550 | 0.830 = 38.9°Be′ | 0.757 = 55.4°Be′ | 0.850 = 34.9°Be′ | 1.8 |
| 75 | | 0.840 = 37.0°Be′ | 0.763 = 53.9°Be′ | 0.855 = 34.0°Be′ | |
| 80 | | 0.850 = 34.9°Be′ | 0.769 = 52.5°Be′ | 0.860 = 33.0°Be′ | 2.0 |
| 85 | | 0.855 = 34.0°Be′ | 0.774 = 51.3°Be′ | 0.865 = 32.0°Be′ | |
| 90 | | 0.860 = 33.0°Be′ | 0.779 = 50.1°Be′ | 0.870 = 31.1°Be′ | 3.0 |
| 95 | 4% | residue | | | |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF RANGER, TEX., CRUDE OIL.

Specific Gravity, 0.829; °Be′, U. S. 38.9°; °Be′ Tag 39.2°.
Summary: 57.4°Be′ Gasoline = 30.0%; 41.1°Be′; Kerosene = 30.0%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 154 | ............... | ............... | ............... |
| 5 | 239 | 0.705 = 69.2°Be′ | 0.705 = 69.2°Be′ | 0.717 = 65.8°Be′ |
| 10 | 268 | 0.729 = 62.5°Be′ | 0.717 = 65.8°Be′ | 0.737 = 60.5°Be; |
| 15 | 294 | 0.745 = 58.4°Be′ | 0.726 = 63.4°Be′ | 0.752 = 56.6°Be′ |
| 20 | 325 | 0.759 = 55.2°Be′ | 0.734 = 61.3°Be′ | 0.765 = 53.4°Be′ |
| 25 | 362 | 0.771 = 52.0°Be′ | 0.742 = 59.2°Be′ | 0.777 = 50.6°Be′ |
| 30 | 390 | 0.783 = 49.2°Be′ | 0.749 = 57.4°Be′ | 0.789 = 47.8°Be′ |
| 35 | 423 | 0.796 = 46.4°Be′ | 0.755 = 55.9°Be′ | 0.800 = 45.3°Be′ |
| 40 | 460 | 0.805 = 44.2°Be′ | 0.762 = 54.2°Be′ | 0.811 = 42.9°Be′ |
| 45 | 494 | 0.817 = 41.7°Be′ | 0.768 = 52.7°Be′ | 0.822 = 40.6°Be′ |
| 50 | 528 | 0.827 = 39.6°Be′ | 0.774 = 51.3°Be′ | 0.831 = 38.7°Be′ |
| 55 | 558 | 0.835 = 38.0°Be′ | 0.779 = 50.1°Be′ | 0.837 = 37.5°Be′ |
| 60 | 582 | 0.840 = 37.0°Be′ | 0.784 = 49.0°Be′ | 0.843 = 36.3°Be′ |
| 65 | vacuum | 0.851 = 34.8°Be′ | 0.789 = 47.8°Be′ | 0.858 = 33.4°Be′ |
| 70 | " | 0.865 = 32.1°Be′ | 0.795 = 46.4°Be′ | 0.870 = 31.1°Be′ |
| 75 | " | 0.875 = 30.2°Be′ | 0.800 = 45.3°Be′ | 0.880 = 29.3°Be′ |
| 80 | " | 0.885 = 28.4°Be′ | 0.805 = 44.2°Be′ | 0.890 = 27.4°Be′ |
| 85 | " | 0.895 = 26.6°Be′ | 0.810 = 43.2°Be′ | 0.897 = 26.2°Be′ |
| 90 | " | 0.900 = 25.7°Be′ | 0.815 = 42.1°Be′ | 0.923 = 21.8°Be′ |
| 95-100 | residue | 0.947 = 17.9°Be′ | 0.823 = 40.4°Be′ | ..................... |

### FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF KENTUCKY CRUDE OIL.

Specific Gravity, 0.8415; °Be′ U. S. 36.7°; °Be′ Tag.
Summary: Gasoline = 27.5%; Kerosene = 22.5%.

| % | Temp. °F | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 186 | .... | ............... | ............... |
| 5 | 259 | 0.720 | 0.720 = 65.0°Be′ | 0.728 = 63.8°Be′ |
| 10 | 285 | 0.737 | 0.728 = 63.8°Be′ | 0.742 = 59.2°Be′ |
| 15 | 310 | 0.748 | 0.735 = 61.0°Be′ | 0.755 = 55.9°Be′ |
| 20 | 342 | 0.762 | 0.741 = 59.4°Be′ | 0.769 = 52.5°Be′ |
| 25 | 387 | 0.776 | 0.748 = 57.6°Be′ | 0.784 = 48.9°Be′ |
| 30 | 422 | 0.793 | 0.756 = 55.6°Be′ | 0.796 = 46.2°Be′ |
| 35 | 458 | 0.800 | 0.762 = 54.2°Be′ | 0.805 = 44.2°Be′ |
| 40 | 502 | 0.811 | 0.768 = 52.7°Be′ | 0.816 = 41.9°Be′ |
| 45 | 542 | 0.822 | 0.774 = 51.3°Be′ | 0.827 = 39.6°Be′ |
| 50 | 582 | 0.833 | 0.780 = 49.9°Be′ | 0.839 = 37.1°Be′ |
| 55 | 600 | 0.845 | 0.786 = 48.5°Be′ | 0.849 = 35.1°Be′ |
| 60 | 600 | 0.853 | 0.791 = 47.3°Be′ | 0.857 = 33.6°Be′ |
| 65 | 600 | 0.862 | 0.797 = 46.0°Be′ | 0.871 = 30.9°Be′ |
| 70 | 600 | 0.880 | 0.803 = 44.7°Be′ | 0.887 = 28.0°Be′ |
| 75 | 600 | 0.895 | 0.809 = 43.4°Be′ | 0.919 = 22.4°Be′ |
| 80 | residue | 0.943 | 0.817 = 41.7°Be′ | |

### FRACTIONAL GRAVITY DISTILLATION OF CRUDE OIL FROM EASTERN ALLEN COUNTY, MORAN, KAN.

Sp. Gr. = .8775
Be. Gr. = 29.7

| Per Cent | Temp. °F | Gravity of Fraction | Gravity of Total Dist. | Gravity of Stream |
|---|---|---|---|---|
| 0 | ... | ... | .......... | .......... |
| 5 | 342 | .753 | .753 = 56.4 | .762 = 54.2 |
| 10 | 384 | .771 | .762 = 54.2 | .778 = 50.3 |
| 15 | 422 | .788 | .770 = 52.2 | .796 = 46.2 |
| 20 | 459 | .804 | .779 = 50.1 | .810 = 43.2 |
| 25 | 490 | .816 | .786 = 48.5 | .822 = 40.6 |
| 30 | 529 | .829 | .792 = 47.1 | .835 = 37.9 |
| 35 | 562 | .840 | .800 = 45.3 | .844 = 36.2 |
| 40 | 592 | .849 | .806 = 44.0 | .853 = 34.3 |
| 45 | 600 | .858 | .812 = 42.7 | .863 = 32.4 |
| 50 | 600 | .868 | .817 = 41.7 | .874 = 30.4 |
| 55 | 600 | .881 | .823 = 40.4 | .886 = 28.2 |
| 60 | 600 | .891 | .829 = 39.1 | .896 = 26.4 |
| 65 | 600 | .901 | .834 = 38.1 | .904 = 25.0 |
| 70 | 600 | .907 | .839 = 37.1 | .912 = 23.6 |
| 75 | 620 | .921 | .845 = 35.9 | .946 = 18.0 |
| Residue | ... | .972 | .853 = 34.3 | .......... |

# Chemical Constitution of Petroleum

Petroleum is composed of carbon and hydrogen in chemical combination known as hydrocarbons. In conjunction with the carbon and hydrogen there frequently is oxygen, nitrogen and sulphur in much smaller amounts.

In crude oils the amount of carbon varies from 80 to 89%, the hydrogen from 10 to 15%, oxygen from 0.0 to 5.0%, nitrogen from 0.0 to 1.8% and sulphur from .01 to 5.0%.

Typical ultimate analyses of petroleum products are as follows:

| | Carbon | Hydrogen | Sulphur | Nitrogen | Oxygen |
|---|---|---|---|---|---|
| Pennsylvania Crude. . . | 86.06% | 13.88% | 0.06% | 0.00% | 0.00% |
| Texas Crude. . . . . . . . . . . | 85.05 | 12.30 | 1.75 | 0.70 | 0.00 |
| California Crude. . . . . | 84.00 | 12.70 | 0.75 | 1.70 | 1.20 |
| Mexican Crude. . . . . . . . | 83.70 | 10.20 | 4.15 | .... | .... |
| Oklahoma Crude. . . . . . | 85.70 | 13.11 | 0.40 | 0.30 | .... |
| Kas. Crude (Towanda) . | 84.15 | 13.00 | 1.90 | 0.45 | .... |
| Kansas Residuum. . . . . . | 85.51 | 11.88 | 0.71 | 0.32 | 0.63 |
| Healdton (Okla.) Crude. | 85.00 | 12.90 | 0.76 | .... | .... |
| Kansas Air Blown Residuum. . . . . . . . . . . | 84.37 | 10.39 | 0.42 | 0.21 | 4.61 |
| Byerlite Pitch. . . . . . . . . | 87.61 | 9.97 | 0.55 | 0.29 | 1.58 |
| Grahamite. . . . . . . . . . . . | 87.20 | 7.50 | 2.00 | 0.20 | ... |
| Trinidad Asphalt. . . . . . | 82.60 | 10.50 | 6.50 | 0.50 | .... |
| Commercial Gasoline . . | 84.27 | 15.73 | 0.00 | 0.00 | 0.00 |
| Kerosene. . . . . . . . . . . . . | 84.74 | 15.26 | 0.01 | 0.00 | 0.00 |
| Lubricating Oil. . . . . . . . (Paraffin) | 85.13 | 14.87 | 0.01 | .... | .... |
| Lubricating Oil. . . . . . . . (Naphthene) | 87.49 | 12.51 | 0.01 | .... | .... |
| Benzol. . . . . . . . . . . . . . . | 92.24 | 7.76 | 0.00 | 0.00 | 0.00 |

**Paraffin** ($C_nH_{2n+2}$) **hydrocarbons** largely compose the light or more volatile constituents of all petroleum. They are "saturated" hydrocarbons and have a very low ration of specific gravity to distilling temperature, are not acted upon by concentrated sulphuric acid or by fuming sulphuric acid (oleum), are not nitrated by nitric acid and are extremely resistant to all chemical reactions. The chief differences in petroleum are in the heavy constituents, the heavy hydrocarbons of the paraffin series being found chiefly in Pennsylvania and some Mid-Continent oils.

**Naphthenes** ($C_nH_{2n}$) ring or cyclic compounds are less common hydrocarbons in lighter portions of petroleum, but commonly found as heavy hydrocarbons of petroleum. They have a higher ratio of specific gravity to distilling temperature than the paraffin comopunds, are resistant to the action of sulphuric acid and some types may be distinguished by the "formolit" reaction. Oils containing light naphthenes are found in Russia and Louisiana. All heavy oils contain naphthenes.

## $C_nH_{2n}$ (NAPHTHENES) POLYMETHYLENE SERIES.

| | Formula | Boiling Temperature | Gravity |
|---|---|---|---|
| Cyclopropane | $C_3H_6$ | —35°C = —31°F | ............ |
| Cyclobutane | $C_4H_8$ | +12°C = 54°F | .709 = 67.5°Be' |
| Cyclopentane | $C_5H_{10}$ | 49°C = 120°F | .769 = 52.1°Be' |
| Cyclohexane | $C_6H_{12}$ | 81°C = 178°F | .799 = 45.2°Be' |
| Cycloheptane | $C_7H_{14}$ | 117°C = 243°F | .089 = 43.1°Be' |
| Methyl Cyclopentane | $C_6H_{12}$ | 72°C = 162°F | .766 = 52.8°Be' |
| Dimethyl Cyclopentane | $C_7H_{14}$ | 91°C = 196°F | .778 = 50.0°Be' |
| Methyl Cyclohexane | $C_7H_{14}$ | 98°C = 208°F | .778 = 50.0°Be' |
| Dimethyl Cyclohexane | $C_8H_{16}$ | 118°C = 244°F | .781 = 49.3°Be' |
| Trimethyl Cylohexane | $C_9H_{18}$ | 198°C = 388°F | .787 = 47.9°Be' |

**Aromatic or Benzene Hydrocarbons** ( $C_nH_{2n-6}$ ) exist to some extent in certain California petroleums and have a very high ratio of specific gravity to distilling temperature. Gasoline made from the California petroleum is heavier than light gasoline with the same end point made from Mid-Continent petroleum. The aromatic compounds are acted upon by nitric acid forming nitro products. They are formed from paraffin and naphthene hydrocarbons by pyrogenic decomposition at temperatures above 1000°F. The production of aromatic compounds from petroleum has not been commercially satisfactory on account of incomplete conversion and difficulty of freeing from paraffin hydrocarbons.

**Olefines or Ethylenes** ($C_nH_{2n}$) are "unsaturated" hydrocarbons, rarely if ever existing naturally in crude oil but commonly resulting from its exposure to high temperatures. These compounds contain less hydrogen and more carbon than paraffin hydrocarbons and are capable of taking in more hydrogen. They are removed from aromatic compounds, paraffin compounds and naphthene compounds by the action of concentrated sulphuric acid in the usual process of refining gasoline. These hydrocarbons give gasoline, to a large extent, its disagreeable odor before refining. Their combination with sulphur gives a more intense odor. Each of these groups of hydrocarbons is supposed to exist in a complete series, represented by the general formula given. The paraffin or methane series of "saturated" hydrocarbons has been fairly well worked out and is given in the following table:

According to Hofer, the following olefines have been isolated from "North American" petroleum:

| | | | | | |
|---|---|---|---|---|---|
| Ethylene | $C_2H_4$ | Heptylene | $C_7H_{14}$ | Dodecylene | $C_{12}H_{24}$ |
| Propylene | $C_3H_6$ | Octylene | $C_8H_{16}$ | Decatrilene | $C_{13}H_{26}$ |
| Butylene | $C_4H_{10}$ | Nonylene | $C_9H_{18}$ | Cetene | $C_{16}H_{32}$ |
| Amylene | $C_5H_{10}$ | Decylene | $C_{10}H_{20}$ | Cerotene | $C_{27}H_{54}$ |
| Hexylene | $C_6H_{12}$ | Endecylene | $C_{11}H_{22}$ | Melene | $C_{30}H_{60}$ |

If the residue contains much wax, the crude is known as paraffin base oil, but if napthenes or similar hydrocarbons predominate, it is an "asphalt" base oil. Practically the "asphalt" is determined by the solubility of the solid hydrocarbons in pentane and by the gravity and physical character of the residue.

Among the light hydrocarbons of petroleum, either existing naturally or pyrogenically produced, the relation of the specific gravity to the distilling temperature affords a simple and practical method of estimating the amount of olefin, paraffin and aromatic compounds. This relation is set forth in the curves on page 227.

The value of crude oil is not measured by its ultimate analysis or by its "base" so much as by the amount of volatile constituents which it contains. The amount of volatile constituents obtained from various crude oils is shown by the curves on page 121.

# Paraffin Hydrocarbons in Petroleum

| Name | Baume' Gravity | Sp. Gr. Liquid 15.5°C | Formula | Melting Point | Boiling Point | Molecular Weight |
|---|---|---|---|---|---|---|
| **GASEOUS HYDROCARBONS (Natural Gas)** | | | | | | |
| Methane | ... | ..... | $CH_4$ | —184.0°C | —165.0°C | 16.03 |
| Ethane | 194 | 0.432 | $C_2H_6$ | —171.4 | — 93.0 | 30.05 |
| Propane | 142 | 0.525 | $C_3H_8$ | —195.0 | — 45.0 | 44.07 |
| Butane | 109 | 0.585 | $C_4H_{10}$ | —135.0 | + 1.0 | 58.08 |
| **"GASOLINE" HYDROCARBONS** | | | | | | |
| Pentane | 92.2 | 0.630 | $C_5H_{12}$ | .... | 36.3 | 72.10 |
| Hexane | 78.9 | 0.670 | $C_6H_{14}$ | .... | 69.0 | 86.12 |
| Heptane | 70.9 | 0.697 | $C_7H_{16}$ | .... | 98.4 | 100.13 |
| Octane | 65.0 | 0.718 | $C_8H_{18}$ | .... | 125.5 | 114.15 |
| Nonane | 59.2 | 0.740 | $C_9H_{20}$ | — 51.0 | 150.0 | 128.16 |
| Decane | 56.7 | 0.750 | $C_{10}H_{22}$ | — 31.0 | 173.0 | 242.18 |
| Undecane | 54.2 | 0.760 | $C_{11}H_{24}$ | — 26.0 | 195.0 | 156.20 |
| **HEAVY LIQUID HYDROCARBONS (Kerosene)** | | | | | | |
| Duodecane | 51.8 | 0.770 | $C_{12}H_{26}$ | — 12.0 | 214.0 | 170.22 |
| Tridecane | 46.8 | 0.792 | $C_{13}H_{28}$ | — 6.0 | 234.0 | 184.24 |
| Tetradecane | 45.0 | 0.800 | $C_{14}H_{30}$ | + 5.0 | 252.0 | 198.25 |
| Pentadecane | 43.5 | 0.807 | $C_{15}H_{32}$ | 10.0 | 270.0 | 212.26 |
| Hexadecane | 41.8 | 0.815 | $C_{16}H_{34}$ | 28.0 | 287.0 | 226.27 |
| Heptadecane | 40.3 | 0.822 | $C_{17}H_{36}$ | 22.0 | 295.0 | 240.28 |
| Octadecane | 38.6 | 0.830 | $C_{18}H_{38}$ | 28.0 | 317.0 | 254.30 |
| **HEAVY SOLID HYDROCARBONS** | | | | | (vacuo) | |
| Eicosane | 37.2 | 0.837 | $C_{20}H_{42}$ | 37.0 | 117.5 | 282.34 |
| Tricosane | 36.5 | 0.841 | $C_{23}H_{48}$ | 48.0 | 138.0 | 325.38 |
| Tetracosane | ... | .... | $C_{24}H_{50}$ | 51.0 | 145.5 | 338.39 |
| Pentacosane | ... | .... | $C_{25}H_{52}$ | 54.0 | 152.5 | 352.41 |
| Hexacosane | ... | .... | $C_{26}H_{54}$ | 56.0 | 160.0 | 366.43 |
| Mericyl | ... | .... | $C_{27}H_{56}$ | 59.4 | 167.0 | 370.45 |
| Octocosane | ... | .... | $C_{28}H_{58}$ | 60.0 | 173.5 | 384.47 |
| Nonocosane | ... | .... | $C_{29}H_{60}$ | 63.0 | 179.0 | 398.48 |
| Ceryl | ... | .... | $C_{30}H_{62}$ | 65.6 | 186.0 | 422.49 |
| Pentriacontane | ... | .... | $C_{31}H_{64}$ | 68.0 | 193.5 | 436.52 |
| Duotriacontane | ... | .... | $C_{32}H_{66}$ | 70.0 | 201.0 | 450.53 |
| Tetratriacontane | ... | .... | $C_{34}H_{70}$ | 72.0 | 215.0 | 478.56 |
| Pentatriacontane | 35.4 | 0.846 | $C_{35}H_{72}$ | 75.0 | 222.0 | 492.58 |

There is no natural petroleum composed exclusively of the paraffin series of hydrocarbons, even Pennsylvania and Garber, Oklahoma, crude oils having members of other series. The main body of the light petroleum is made up of paraffin hydrocarbons and the heavy residues are largely made up of napthenes.

# Typical Refinery Practice

There is much variation in the practice of petroleum distillation in different refineries. This depends to a large extent upon the character of the crude oil used, the market to which the refiner sells and the ability of the refiner both as to knowledge and equipment.

The following outlines the progressive distillation and treatment of crude oil in a typical refinery:

1. **Crude Benzine** (Gasoline and Naphtha) includes all of the light distillate which vaporizes up to 410°F. In the ordinary Mid-Continent or Texas petroleum, 420°F indicates a gravity of the stream of distillate from the condenser in the receiving house of 46.5°Be' to 47.0°Be'. The gravity of the total distillate at this point varies with different types of crude. In some crudes this will be as high as 64.0° gravity, in others as low as 50.0°. For example, referring to pages 122 to 127, Burkburnett crude boiling at 410°F has a gravity of 59.7° of the total benzine and a stream gravity of 46.5°Be'; Bixby, Okla., crude benzine at 410°F has a gravity of 58.0°Be' and a stream gravity of 46.7°Be'; Cushing, Okla., crude benzine at 410°F has a gravity of 59.7°Be' and a stream gravity of 47.0°Be'; Billings, Okla., crude has a gravity of 60°Be' at 410°F and a stream gravity of 46.5°Be'; Ranger, Texas, crude oil has a benzine gravity of 410°F of 56.6°Be' and a stream gravity of 46.7°Be'. The gravity of crude benzine depends upon the initial boiling point of the crude, the relative proportion of the different paraffin constituents and the chemical series of hydrocarbons to which the crude belongs (see page 227.

The crude benzine is run off with direct fire under the still, though after a temperature of 212°F is reached some steam may be put in. The steam decidedly sweetens the product and brings over the benzine at a lower temperature. In the use of steam the distillation must be entirely governed by the gravity of the stream in the receiving house and not by temperatures. In cases where the crude is of good quality it is not necessary to treat the benzine as it may merely be redistilled with steam. In many cases the refiner puts a good dephlegmator over on his crude still and makes a marketable gasoline without either treating it with acid or redistilling it with steam.

When a high sulphur or low grade petroleum is treated the distillate is put into an agitator with sulphuric acid, the mixing being perfected by blowing air through the acid in the bottom of the agitator, thus contacting it with all portions of the benzine. The acid is drained out and the benzine washed with water. Caustic soda or "doctor" solution is added to neutralize the acid and the benzine is thoroughly washed to remove the last traces of caustic or sulfonates. The benzine is redistilled in a steam still to give a gasoline of 58 to 60 gravity and about 430 end point, this depending largely upon the perfection of the dephlegmator. The last portion of the distillate is naphtha if a gasoline of high Baume' is desired. High gravity crudes are blended with low gravity crudes to eliminate the naphtha fraction.

2. **Kerosene or Water White Distillate** comes over just after the crude benzine, with the gravity of the stream in the receiving house at about 37.0 and a vapor temperature of 572°F. This will give a kerosene ordinarily of a 41 gravity, but this again varies greatly with the type of the oil. For example, a certain Wyoming crude

oil under these conditions gives a 31.0° kerosene, whereas Cushing, Okla., and Bixby, Okla., crude oils give a 41.0° to 42.0° gravity kerosene. Pine Island cracked oil gives a 33-34°Be′ kerosene. In distilling kerosene from the crude it is desirable to stop before there is discoloration from decomposition or cracking. Cracking may be very largely prevented and kerosene very greatly sweetened by using open steam throughout the entire distillation. The water white distillate or first run kerosene is now treated with acid and caustic in the agitator and exposed to heat, air and light in a shallow tank or bleacher in which all water is settled out. If the kerosene after treatment is not water white or has too high an end point it is redistilled with superheated open steam. The residue in the still may be mixed with the solar oil.

3. **Solar Oil or Distillate Oil** is taken out immediately following the kerosene, being a crude distillate not subjected to refining, and sold for use in explosion engines and as a high grade special fuel oil. The making of this product depends upon the market. It may be about a 36 gravity product or it may be combined with gas oil or straw oil.

4. **Gas Oil** is taken immediately following the distillate oil or kerosene and its distillation is continued until the residuum in the still has a gravity of 23 to 26°Be′. It is distinctly a destructive distillation and the yield depends largely upon the method and rate of firing. Gas oil is used in making gas and contains a considerable amount of olefins and cracked products, and is not refined except for special purposes. If a gas oil fraction low in olefins (straw oil) is desired it is necessary to distill using open steam and direct fire. Straight firing gives a more fluid residue on account of cracking.

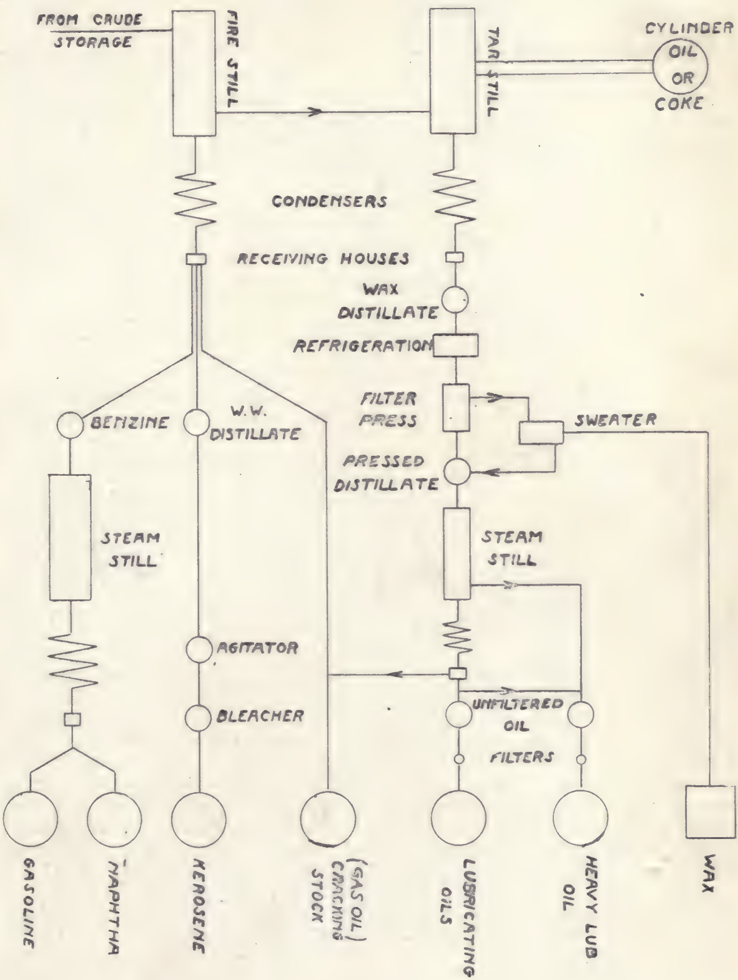
5. **Residuum or tar** is sold as **fuel oil** or it may be used to produce lubricating oil. In the latter case it may be put into tar stills and run down to **coke**. The distillate is treated, refrigerated and the **paraffin** is removed by the filter press. If the crude oil contains no wax then the lubricants may be made by vacuum, steam or gas distillation, and the distillate is only filtered through fullers earth for use.

6. The filtrate from the paraffin wax or **pressed distillate** may be redistilled with steam to produce lubricating oil of the desired gravity, viscosity and cold test. The heaviest residual oil is the steam cylinder stock. Steam cylinder stock is the residue from the steam distillation of light colored crude oils, such as Cabin Creek, W. Va., and Ranger, Tex. The most careful refining is required for the automobile cylinder oil in order to obtain low fixed carbon to prevent separation of free carbon in the cylinder.

7. When **asphalt** is desired the residue from the gasoline and kerosene may be distilled by blowing superheated steam through it until the desired consistency is reached. Asphalt base oils or cracked paraffin base oils are necessary to make first class asphalt. An outline of the methods used for producing asphalts and road oils is given on page 191. Frequently, particularly for road oils, the stock remaining after cracking heavy gas oil is run down to a semi-solid or solid consistency. This gives a specially valuable road oil on account of its high asphalt content, good hardening or drying properties, low viscosity and excellent penetration.

For refining by cracking see pages 209-232.

For illustration of a refinery operation see flow sheet on page 133.




TYPICAL FLOW SHEET OF COMPLETE REFINERY

## PYROMETRY APPLIED TO PETROLEUM DISTILLATION.

C. Benton Kennedye, Pyrometric Engineer.

Refinery operation is largely dependent upon temperature. Considerable thought and study should be given to its correct measurement.

The most widely used instruments for measuring high temperatures are the Thermo-Electric Pyrometers. The improved high resistance Thermo-Electric Pyrometer for refinery application consists of a thermo-couple inserted eighteen inches into the still and a galvanometer. The thermo-couple is formed of two wires of different alloys welded at one end and when this junction is heated by the oil or vapor it generates a small current of electricity. The current thus generated operates a millivolt meter. As the temperature in the still or vapor line increases or decreases, the millivoltage generated by the thermo-couple is increased or decreased in direct proportion and is indicated on the instrument in degrees.

The advantages of Pyrometers over Thermometers are:

A. Ease of observation.
B. Adaptability—recorders can be located any distance from stills or cracking plant.
C. Robustness of apparatus, ease of repair.
D. Availability for automatically making permanent records of temperature extending over considerable intervals of time.
E. Indications can be noted and controlled from one central point by means of switch.

The pyrometers of one manufacturer are most popular in the oil industry owing to the fact that they maintain a free field service with competent engineers who periodically check up their equipment.

A recent practical development is known as a Resistance Thermometer, which will measure temperatures with great accuracy from three hundred degrees Fahr. below zero to eighteen hundred degrees Fahr. above zero. A coil of platinum or pure nickel wire with suitable protecting tube similar to diagram on the following page, is installed in the vapor line just before entering the condenser and another bulb installed in a similar manner in the still. With a constant source of current passing through the coil, the resistance increases or decreases, depending upon the temperature of the coil of wire. This change in resistance can be easily measured and an adjustable resistance balancing the resistance of the bulb and a galvanometer or deflector shows when the balance is reached. With suitable switching apparatus, any number of temperatures can be indicated by the one instrument. Gasoline of any desired end point may be easily secured by maintaining that temperature in the vapor line.

These instruments are accurate within one degree F. They are entirely unaffected by the length of leads connecting the bulb and instrument or the temperature of the leads, and there are no cold junctions.

The rapidly growing tendency of the trade to purchase oil on distillation tests as well as on gravity, makes it desirable for the refiner to make runs on oil and vapor temperatures rather than on tailhouse gravities alone.

In the cracking processes, the temperatures of the oil being treated must be maintained within very narrow ranges and for this purpose accurate pyrometers are absolutely necessary.

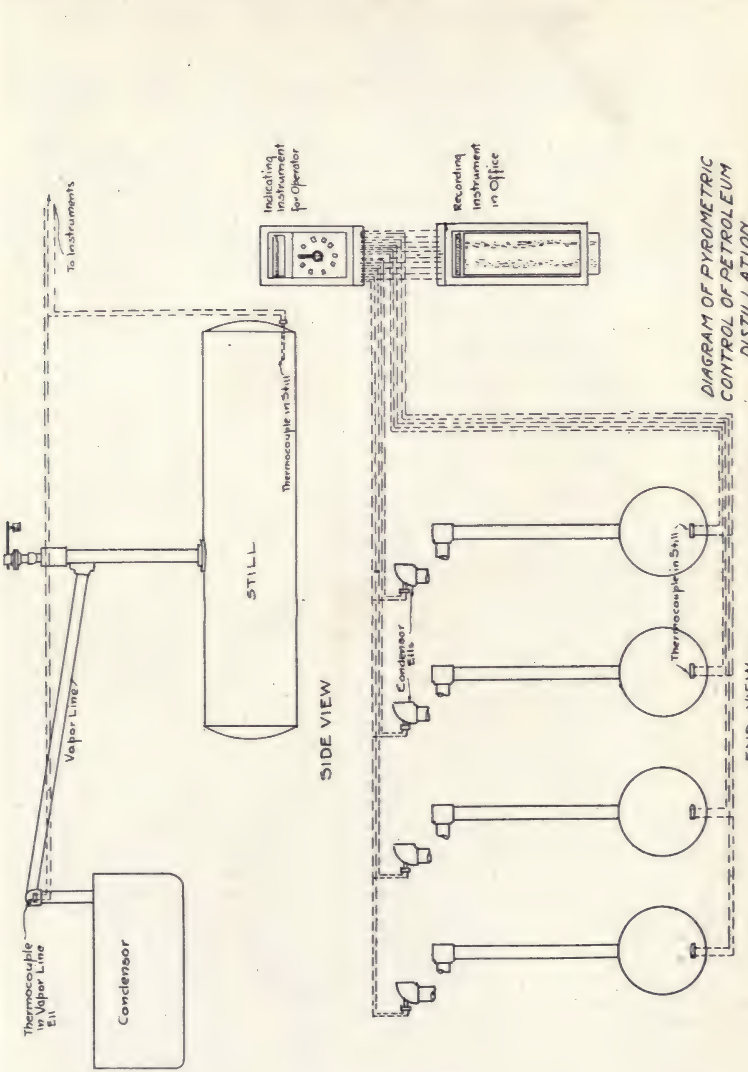



DIAGRAM OF PYROMETRIC CONTROL OF PETROLEUM DISTILLATION

# Cause of Color and Odor in Refined Petroleum

Most distillates from petroleum contain sufficient foreign matter to give an undesirable odor or a yellowish to red color.

The odor in natural distillates is due ordinarily to sulphur compounds, characteristic of which is hydrogen sulphide. Gasoline or light hydrocarbons produced by cracking have a more or less offensive odor even though sulphur is not present in appreciable quantity. In a general way, color is present in proportion as the odor is more disagreeable. The color of petroleum products is thought to be largely due to nitrogen compounds. Light hydrocarbons produced by cracking have a higher color the larger the amount of nitrogen in the heavy oils cracked, as a general rule. Cracked products from paraffin hydrocarbons such as those from Oklahoma give a yellowish color in the distillate above 300°F, though they may be colorless below 300°F. California and Mexico cracked gasoline give a red color, which is not noticeable immediately upon distilling, but becomes more intense as the gasoline is exposed to the action of the acid. This coloring matter on standing largely settles out or is oxidized so that the redistilled gasoline may be free from color.

Kerosene, the first refined product of petroleum marketed on a large scale, was a yellow or dark red liquid. It was first produced from coal, and it was found in 1857 that "coal oil" could be deodorized and decolorized by treatment with sulphuric acid, and this is the process that is in general use at the present time. 66°Be' sulphuric acid is ordinarily used, as it reacts upon the unsaturated compounds, the sulphur compounds and the nitrogenous compounds in the oil by forming substances which dissolve largely in the sulphuric acid. The shrinkage of the oil treated may vary from almost nothing up to 10%, depending upon the character of the oil being refined. In ordinary natural distillates, one pound of acid per barrel is commonly sufficient, but with cracked oil as much as 10 pounds of acid are often required. Even then the treatment is often not sufficiently severe, and oleum or Nordhausen sulphuric acid, which contains an excess of sulphur trioxide, is necessary. This is the case with California and Towanda oil. After treatment with sulphuric acid, thorough washing and neutralization with caustic soda is always necessary. Other substances used for neutralizing the acid and acid sulfonates are soda ash, lime, silicate of soda and sodium plumbite.

Other chemicals may be quite successfully used in removing the odor of cracked gasoline, among these being sodium plumbite, copper oxide, manganese dioxide, potassium permanganate, sodium chromate, aluminum chloride and chlorine.

Dry hydrochloric acid gas (hydrogen chloride, HCl) is often highly effective in treating gasoline to remove the color.

The "bloom" or fluorescence of mineral oils is supposed to be due to the presence of asphalt-like or pitchy material in colloidal condition. This is overcome by the use of mono-nitro-napthalene ($C_{10}H_7NO_2$) in small amounts. The physical means of removing color and to some degree odor is by filtration through fuller's earth. This is common practice with lubricating oils.

## THE EFFECT OF SULPHUR IN THE REFINING OF PETROLEUM.

Sulphur is present in all petroleums. (See page 128.) It exists in the elementary form dissolved in the oil or in a chemically combined form as the sulphides of hydrocarbon groups. When it is found in very large amount there is usually a considerable amount of free or elementary sulphur. The alkyl or organic sulphides give to petroleum its characteristic odor. High sulphur petroleum residues such as Trinidad asphalt have characteristic odors of complex sulphur compounds. Lighter gasoline-bearing oils such as the Ohio and the Butler County, Kansas, oils have characteristic odors varying from that of pure hydrogen sulphide to that of the complex organic sulphides such as exist in natural asphalt. A typical distillation of a heavy crude oil by means of steam shows the following results as to distribution of sulphur:

| Fraction | Specific Gravity | Sulphur |
|---|---|---|
| 0-10% | 0.868 = 31.3° Be' | 0.39% |
| 10-20% | 0.877 = 29.6° Be' | 0.35% |
| 20-30% | 0.895 = 26.4° Be' | 0.43% |
| 30-40% | 0.909 = 24.0° Be' | 0.53% |
| 40-50% | 0.920 = 22.1° Be' | 0.70% |
| 50-60% | 0.920 = 22.1° Be' | 0.70% |
| 60-70% | 0.917 = 22.7° Be' | 0.70% |
| 70-80% | 0.917 = 22.7° Be' | 0.56% |

This condition does not hold in the case of all oils, particularly the oils from Butler County, Kansas, which are characterized by the giving off of the rather large amount of hydrogen sulphide in the early part of the distillation.

Sulphur causes trouble in the refinery in the purification of the distilled products and in the corrosive effect of the oxidized sulphur, particularly on the condenser pipes.

At the time that the first sulphur oils were discovered in Ohio (.8% sulphur) they brought a price of only 14c per barrel, while at the same time the Pennsylvania oils (0.04% sulphur) sold at $2.25 per barrel. According to Frash it is a comparatively simple matter to free petroleum of elementary sulphur or hydrogen sulphide, but the sulphur compounds, which are the cause of the offensive odor, are very stable and cannot easily be broken up into hydrogen sulphide or other sulphur compounds which can be eliminated. It was because of the presence of these stable compounds that high sulphur oils for many years resisted all efforts to refine it. These complex sulphur compounds have the peculiarity of dissolving a number of metallic oxides. When the oil is saturated with all of the oxide which can be carried, the disagreeable odor disappears. It tends to reappear, however, when an attempt is made to separate the metal from the oil unless more oxide is used than is necessary to precipitate all of the sulphur, in which case complete desulphurization of the petroleum is effected. The Frash method, which has been successfully used for nearly thirty years by the Standard Oil Co., consists in the use of 1,000 pounds of the copper oxide to 2,000 barrels of distillate. The copper is recovered by filtering and roasting.

In distillation the chemical action of the sulphur may result from the direct combination of the sulphur with the iron or by the oxidation of the sulphur with formation of sulphonic acids, which pit the iron, particularly of the condensers.

The acid withdrawn from the agitator after treatment of oils to

remove color and odor is a black viscous material. Much of this sulphuric acid may be recovered by digestion to decompose the complex organic compounds and oxidation usually with air to burn out the carbonaceous material and preserve as much of the sulphur as $SO_3$ instead of driving it off as $SO_2$.

# Gasoline

Gasoline as now found on the market is a mixture of petroleum hydrocarbons, having an initial boiling point of from 80°F to 160°F, an end boiling point of from 368°F to 450°F, gravity of 56° to 61°Be'., a sweet to oily aroma and a water white color.

The particular hydrocarbons composing it belong to a general group known as the paraffins. Other types of hydrocarbons are occasionally present in a very small amount. These are known as olefins and as benzenes. The olefins are removed by a thorough treatment with sulphuric acid, but the benzenes remain if originally present.

Ordinary gasoline made by the natural distillation of Mid Continent crude oil will contain several or all of the following substances:

| Name | Boiling point | Specific gravity | Baume'Gravity |
|---|---|---|---|
| 1. Pentane | 97°F | 0.630 | 92.2° |
| 2. Hexane | 156°F | 0.670 | 78.9° |
| 3. Heptane | 209°F | 0.697 | 70.9° |
| 4. Octane | 258°F | 0.718 | 65.0° |
| 5. Nonane | 302°F | 0.740 | 59.2° |
| 6. Decane | 343°F | 0.750 | 56.7° |
| 7. Undecane | 383°F | 0.760 | 54.2° |

The following aromatic compounds are produced by pyrogenic decomposition of heavy hydrocarbons and rarely exist naturally in crude petroleum.

They are produced by the cracking of oil in the vapor phase and at high temperatures and occur in artificial or what has been called "synthetic" gasoline.

| Name | Boiling point | Specific gravity | Baume' gravity |
|---|---|---|---|
| Benzol ($C_6H_6$) | 176°F | 0.880 | 29.1° |
| Toluol ($C_6H_5CH_3$) | 232°F | 0.872 | 30.6° |
| Xylene ($C_6H_4(CH_3)_2$ | 291°F | 0.882 | 28.7° |

A small amount of these hydrocarbons in commercial gasoline very materially affects the gravity.

The character of gasoline is governed almost entirely by its use for automobiles. It is also used to some extent for stove gasoline and for cleaning purposes, in which case it has a lower end point and a higher Baume' gravity.

Gasoline is commonly blended and originates from one or more of the following sources:

1. The natural product distilled from crude oil. This constitutes about 73% of the total on the market (1917-18).

2. As a condensate from natural gas and known as casinghead gasoline. This constitutes about 7% of all gasoline and is always incorporated with heavy hydrocarbons such as naphtha or with gasoline distilled from a heavy crude or with gasoline made by cracking.

3. The light hydrocarbons produced by the pyrogenic decomposition of heavy petroleum residua. This constitutes about 20% of the market gasoline and tends to have a considerable amount of aromatic compounds.

The most desirable properties of gasoline are low end point and a low initial boiling point, the usual refiner's practice being to call everything gasoline which distills up to a temperature of 410°F. This practice in a light crude gives a 58°Be' product, although in the unusually light crudes a 61° product is obtained and in heavy crudes a gravity as low as 54° may be obtained. This heavy gasoline must be blended to make it satisfactory for ordinary market purposes.

Page 227 shows the relation of the boiling point to the specific gravity of ordinary market gasoline. Gasolines containing considerable olefins, aromatics or naphthenes have a higher relation of specific gravity to boiling point than do gasolines composed entirely of paraffin hydrocarbons.

Page 148 shows the relation of the boiling temperature to the percentage distilled over in ordinary commercial gasoline. These curves show that the gravity alone is not a good measure of the quality of a gasoline. For example, a 58° gravity gasoline in one case has an initial boiling point of less than 100°F and in another case has an initial boiling point of 190°F. A naphtha blended with casinghead will have a very high gravity test, but will show a very low initial boiling point and a very high end point.

The method of determining the quality of gasoline is described on page 307.

## U. S. GASOLINE SPECIFICATIONS.

Specifications for standard tests of aviation gasoline, motor gasoline and fuel oil as announced in October, 1918, by the Inter-departmental Committee on Stardardization of Specifications for Petroleum Products.

### AVIATION GASOLINE.

The specifications for aviation gasoline (export, fighting and domestic) as adopted are as follows:

**1. Color.**

The color shall be water white.

Test—Inspection of a column in a standard 4 ounce oil sample bottle.

**2. Foreign Matter.**

The gasoline shall be free from acid, undissolved water and suspended matter.

Acid Test—The residue remaining in the flask after distillation is complete is shaken thoroughly with 1 cc of distilled water. The aqueous extract must not be colored red on addition of a few drops of methyl orange solution. Water and suspended matter would be in evidence in the test for color.

**3. Doctor Test.**

The gasoline shall yield a negative doctor test.

Directions for making doctor test on gasoline:

(a) Preparation of Reagents: Sodium plumbite or "doctor solution." Dissolve approximately 125 grams of sodium hydroxide ($NaOH$) in a liter of distilled water. Add 60 to 70 grams of litharge ($PbO$) and shake vigorously for 15 to 30 minutes or let stand with occasional shaking for at least a day. Allow to settle and decant or siphon off the clear liquid. Filtration through a mat of asbestos may be employed if the solution does not settle clear. The solution should be kept in a bottle tightly stoppered with a cork.

Sulphur—Obtain pure flower of sulphur.

(b) Making a Test:—Shake vigorously together two volumes of

gasoline and one volume of the "doctor solution" (10 cc of gasoline and 5 cc of "doctor solution" in an ordinary test tube; or proportional quantities in a 4 ounce oil sample may be conveniently used). After shaking for about fifteen seconds a small pinch of flowers of sulphur should be added and the tube again shaken for 15 seconds and allowed to settle. The quantity of sulphur used should be such that practically all of the sulphur floats on the surface, separating the gasoline from the "doctor solution."

(c) Interpretation of Results—If the gasoline is discolored, or if the sulphur film is so dark that its yellow color is noticeably masked the test shall be reported as positive and the gasoline condemned as "sour". If the liquid remains unchanged in color and if the sulphur film is bright yellow, or only slightly discolored with gray or flecked with black the test shall be reported negative and the gasoline considered "sweet".

**4. Corrosion and Gumming.**

The gasoline, when subjected to the corrosion test, shall show no gray or black corrosion and no weighable amount of gum.

The apparatus used in this test consists of a freshly polished hemispherical dish of spun copper, approximately 3½ inches in diameter.

Fill this dish to within ⅜ inch of the top with the gasoline to be examined and place the dish upon a steam bath. Leave the dish on the steam bath until all volatile portions have disappeared.

If the gasoline contains any dissolved elementary sulphur the bottom of the dish will be colored gray or black.

If the gasoline contains undesirable gum-forming constituents there will be a weighable amount of gum deposited on the dish. Acid residues will show as gum in this test.

**Interpretation of Results.**

Corrosion—It is specified that no gray or black deposit shall be formed. This wording is intended to admit gasolines that have so small a quantity of sulphur that the deposit is peacock colored.

Gum—It is specified that there shall be no weighable amount of gum. The intention is to refuse admittance to gasoline that shows an amount that can be readily weighed in this style of dish.

The distillation method and apparatus shall conform to those outlined and described in Bureau of Mines Technical Paper No. 166, entitled "Motor Gasoline, Properties, Laboratory Methods of Testing and Practical Specifications."

**Volatility and Distillation Range—Export Grade.**

When 5% of the sample has been recovered in the graduated receiver the thermometer shall not read more than 65°C (149°F) or less than 95°C (203°F).

When 50% has been recovered in the receiver the thermometer shall not read more than 95°C (203°F).

When 90% has been recovered in the receiver the thermometer shall not read more than 150°C (302°F).

When 95% has been recovered in the receiver the thermometer shall not read more than 150°C (302°F) and the end point shall not exceed this temperature by more than 15°C (27°F).

At least 96% must be recovered in the receiver from the distillation.

The distillation loss shall not exceed 2% when the residue in the flask is cooled and added to the distillate in the receiver.

**Volatility and Distillation Range—Fighting Grade.**

When 5% of the samples has been recovered in the graduated receiver the thermometer shall not read more than 70°C (158°F) or less than 60°C (140°F).

When 50% has been recovered in the receiver the thermometer shall not read more than 95°C (203°F).

When 90% has been recovered in the receiver the thermometer shall not read more than 113°C (235°F).

When 96% has been recovered in the receiver the thermometer shall not read more than 113°C (235°F) and the end point shall not exceed this temperature by more than 15°C (27°F).

At least 96% must be recovered in the receiver from the distillation.

The distillation loss shall not exceed 2% when the residue in the flask is cooled and added to the distillate in the receiver.

The United States War Department requires fighting grade to be colored red after inspection and acceptance.

**Volatility and Distillation Range—Domestic Range.**

When 5% of the sample has been recovered in the graduated receiver the thermometer shall not read more than 75°C (167°F) or less than 50°C (122°F).

When 50% has been recovered in the receiver the thermometer shall not read more than 105°C (221°F).

When 90% has been recovered in the receiver the thermometer shall not read more than 155°C (311°F).

When 96% has been recovered in the receiver the thermometer shall not read more than 175°C (347°F).

At least 96% must be recovered in the receiver from the distillation.

The distillation loss shall not exceed 2% when the residue in the flask is cooled and added to the distillate in the receiver.

## MOTOR GASOLINE.

The specifications for motor gasoline are:

**Quality.**

Gasoline to be high grade, refined and free from water and all impurities, and shall have a vapor tension not greater than 10 pounds per square inch at 100°F temperature, same to be determined in accordance with the current "Rules and Regulations for the Transportation of Explosives and Other Dangerous Articles by Freight"—paragraph 1824 (k) as issued by the Interstate Commerce Commission.

**Inspection and Tests.**

Inspection—Before acceptance the gasoline will be inspected. Samples of each lot will be taken at random. These samples immediately after drawing will be retained in a clean, absolutely tight closed vessel and a sample for test taken from the mixture in this vessel directly into the test vessel.

Test—100 cc will be taken as a test sample. The apparatus and method of conducting the distillation test shall be that described in Bureau of Mines Technical Paper No. 166, Motor Gasoline:

(a) Boiling point must not be higher than 60°C (140°F).

(b) 20% of the sample must distill below 105°C (275°F).

(c) 45% must distill below 135°C (275°F).

(d) 90% must distill below 180°C (356°F).

(e) The end of dry point of distillation must not be higher than 220°C (428°F).

(f) Not less than 95% of the liquid will be recovered from the distillation.

**MINERAL SPIRITS—1918.**

1. General Specifications—General specifications for paint and painting materials, issued by the Railroad Administration, in effect at date of opening of bids, shall form part of these specifications.

2. The mineral spirits shall be a hydrocarbon distillate, water white, neutral, clear and free from suspended matter and water. It shall have no darkening effect when mixed with basic carbonate white lead.

3. Properties and Tests—When 100 cc are submitted to continuous distillation in an Engler flask with a condenser 22 inches long and at an angle of 30 degrees with the horizontal and cooled with water, the first drop shall issue from the condenser at a temperature of not less than 265°F and 97 per cent shall distill below 470°F.

4. When 10 cc of the distillate are placed in a glass crystallizing dish 2½ inches in diameter, in a steam bath maintained at a temperature of 212°F and evaporated not more than 0.2 per cent of residue shall remain after 2½ hours.

5. The flash point shall be not less than 85°F when determined by the closed Elliott tester method, the test being made in the usual official manner.

# Summary of Gasoline Inspection Laws

(By Dr. G. W. Gray.)

**Arkansas.**—Gravity shall be taken at 60°F, and marked on tank, can, cask, barrel or other vessel containing said gasoline.

**California.**—No law. Los Angeles has adopted motor transport specification.

**Colorado.**—Gravity shall be taken, but no products shall be offered for sale which contain more than 5 per cent of solid matter.

**Georgia.**—Gravity shall be taken and no product known as gasoline, benzine or naphtha shall be offered for sale unless casks, barrels or packages containing such products are labeled with figures denoting gravity and the words "gasoline" "Benzine" or "naphtha", in large red letters.

**Idaho.**—The standard adopted by the Bureau of Mines shall be the standard for Idaho.

**Indiana**—Gravity shall not be less than 56°Be., and the correction for temperature shall be 1°Be. or 10°F.

**Illinois.**—There is no law except that gasoline must be branded "Condemned for illuminating purposes".

**Iowa.**—Gravity shall be between 80°Be. and 70° Be. Boiling point shall not be below 150°F. and not above 210°F. All other products shall be branded "Substitute for gasoline" and these substitutes shall be sold under label, which label shall be printed in large, legible type, etc., defined as follows:

(a) Per cent of boiling below 135°F.
(b) Per cent of boiling between 135°F and 210°F.
(c) Per cent of boiling between 201°F. and 302°F.
(d) Per cent boiling above 302°F.

Bills of lading and the labels of such substitutes shall call attention to the danger of such low boiling point.

**Kansas**—Gravity must not be heavier than 58°Be., initial boiling point shall not exceed 90°F., end boiling point not above 410°F. All products sold not meeting this test shall be known and sold as "Gasoline under test."

**Michigan**—No law. Grand Rapids, 20 per cent shall distill over at or below 320°F. Fifty per cent shall distill over at or below 300°F. End point not above 450°F. If product does not meet this test, it shall be known as a mixed gasoline-kerosene; Detroit, same law as Grand Rapids, but method of distillation is entirely different. Gasoline passing Grand Rapids specification by their method of distillation, might be rejected by Detroit.

**Minnesota**—Gravity shall be taken and containers shall be marked "Unsafe for illuminating purposes."

**Missouri.**—Gravity must not be less than 58°Be.

**Montana.**—Any gasoline used for heating, burning or power purposes in any automobile, engine or in any machinery which falls below 63°Be., shall be deemed below standard, but nothing in this act shall prevent the sale of a heavier product, when product is sold under its proper name and its specific gravity given.

**Nebraska.**—Gravity shall be taken and marked upon container.

**New Mexico.**—No gasoline for illuminating purposes can be sold which is less than 63° gravity, and it shall be conclusively presumed that all sales are for illuminating purposes, unless containers are marked "Not for illuminating purposes."

**North Carolina.**—The initial boiling point not higher than 158°F; 16 per cent off at 230°F; residue not more than 35 per cent at 302°F.; end point not higher than 437°F.

**North Dakota.**—Gravity shall be taken and all gasoline sold for household purposes shall show not less than 3 per cent off at 158°F. and not more than 6 per cent residue at 248°F.

**Ohio.**—Shall be branded according to its commercial name and with the word "Dangerous".

**Oklahoma.**—Gravity shall be taken. If gravity is greater than 74°F. it shall be deemed unsafe and sale is prohibited for use in vapor stoves or other domestic uses.

**Oregon.**—Gravity shall be not less than 56°Be.

**South Dakota.**—Gas machine gasoline, light gasoline, power gasoline, when made from Mid-continent crude shall be as follows: Gas machine gasoline, not less than 64°Be; residue not more than 4 per cent at 300°F; all off below 350°F. Light gasoline, gravity not less than 60°Be.; residue not over 10 per cent above 300°F. and not over 25 per cent above 350°F. Power gasoline gravity not less than 57° Be; residue not more than 25 per cent at 300°F and not more than 3 per cent at 400°F. Below is a table giving gravities depending upon what crude the products are made from:

| | Gravity in degrees Be' Mid-Continent Field. | Penn. Field |
|---|---|---|
| Gasoline for use in automobile engines and in other gasoline engines should have a gravity of not less than | 57 | 62 |
| Gasoline for household use in stoves, flatirons, gasoline lamps, dry cleaning, etc., should have a gravity of not less than | 62 | 65 |
| Gasoline for use in gas machines for the production of gasoline gas, should have a gravity of not less than | 70 | 80 |
| Naphtha for use in engines and for other purposes should have a gravity of not less than | 55 | |

In describing kerosene or gasoline by its gravity it is necessary to indicate the State or Territory producing the crude petroleum from which the finished product was distilled, because crude petroleum differs in different regions and its products differ likewise. In stating the crude petroleum fields above, the Western is taken to include Texas, Oklahoma, Kansas, Wyoming, Illinois and other oil-producing States in the west-central portion of the United States. The Pennsylvania field includes Pennsylvania, West Virginia and neighboring States.

**South Carolina.**—Flash point not more than 32°F; distillation test not less than 25 per cent off at 230°F; not more than 16 per cent of residue at 302°F; dry point not more than 392°F. Any product not meeting this specification must be sold under the name of "naphtha."

**Tennessee.**—The container shall be branded "Gravity not less than °Be.; unsafe for illuminating purposes; for power purposes only."

**Utah.**—Standards adopted by the Bureau of Mines shall be standard for this State. No product sold shall contain more than 1 per cent of solid matter.

**Washington.**—Shall be inspected for its specific gravity and all containers shall be branded with the specific gravity.

**Wisconsin.**—Containers shall have gravity stamped on same.

**Wyoming.**—Gasoline for household use. Distillation test: Not less than 10 per cent off at 150°F; not less than 50 per cent off at 212°F; not less than 98 per cent off at 325°F. Gasoline for power purposes: Not less than 10 per cent off at 170°F; not less than 50 per cent off at 240°F; not less than 94 per cent off at 350°F.

# Benzinum Purificatum (U. S. Pharmacopoeia)

**Purified Petroleum Benzin.**
Benzin. Purif.—*Petroleum Ether.*

A purified distillate from American petroleum consisting of hydrocarbons, chiefly of the marsh-gas series. Preserve it carefully in well-closed containers, in a cool place, remote from fire.

Purified Petroleum Benzin is a clear, colorless, non-fluorescent, volatile liquid, of an ethereal, or faint, petroleum-like odor, and having a neutral reaction. It is highly inflammable and its vapor, when mixed with air and ignited, explodes violently.

It is practically insoluble in water, freely soluble in alcohol, and miscible with ether, chloroform, benzene, volatile oils and fixed oils, with the exception of castor oil.

Specific gravity: 0.638 to 0.660 at 25°C.

It distils completely between 40°C and 80°C (104°F to 176°F).

Evaporate 10 mils of Purified Petroleum Benzin from a piece of clean filter paper: no greasy stain remains, and the odor is not disagreeable or notably sulphuretted. Not more than 0.0015 Gm. of residue remains on evaporating 50 mils of Purified Petroleum Benzin at a temperature not exceeding 40°C.

Boil 10 mils of Purified Petroleum Benzin for a few minutes with one-fourth its volume of an alcoholic solution of ammonia (1 in 10) and a few drops of silver nitrate T. S.; the liquid does not turn brown (pyrogenous products and sulphur compounds).

Add 5 drops of Purified Petroleum Benzin to a mixture of 40 drops of sulphuric acid and 10 drops of nitric acid in a test tube, warm the liquid for about ten minutes, set it aside for half an hour, and dilute it in a shallow dish with water; no odor of nitrobenzene is evolved.

## NAVY SPECIFICATIONS FOR GASOLINE.

### Regular Gasoline.

The navy specifications for gasoline are as follows:

| | |
|---|---|
| Initial below | 140 |
| 20% off at | 200 |
| 45% off at | 275 |
| 90% off at | 356 |
| End point below | 428 |

### Aero Gasoline.

The aero gasoline (for fighting planes) shall be:
(a) Not more than 5% shall distill below 60°C (140°F).
(b) Not less than 5% shall distill below 70°C (167°F).
(c) At least 50% shall distill below 95°C (202°F).
(d) At least 90% shall distill below 113°C (235°F).
(e) At least 96% shall distill below 125°C (257°F).

### Export Gasoline.

Export gasoline (for use in bombing planes):
(a) Not more than 5% shall distill below 60°C (140°F).
(b) Not less than 5% shall distill below 75°C (167°F).
(c) At least 50% shall distill below 100°C (212°F).
(d) At least 90% shall distill below 125°C (257°F).
(e) At least 96% shall disitll below 150°C (302°F).

### Domestic Gasoline.

Domestic gasoline (for use in training planes):
(a) Not more than 5% shall distill below 60°C (140°F).
(b) Not less than 5% shall distill below 75°C (167°F).
(c) At least 50% shall distill below 105°C (223°F).
(d) At least 90% shall distill below 155°C (311°F).
(e) At least 96% shall distill below 175°C (347°F).

### Comparison of Gasoline and Benzol as Motor Fuel.

| Heat of combustion: | Benzol. | Gasoline. |
|---|---|---|
| B. T. U. per gallon | 132330 | 129060 |
| B. T. U. per pound | 18054 | 20750 |
| Freezing temperature | 41°F | 50°F below Zero |
| Boiling temperature | 170-180 | 130-400°F |
| Rate of evaporation | Slower | Faster |
| Mileage per gallon (comparative) | 110. | 100. |
| Ignition temperature | Higher | Low |
| Preignition from carbon | Less trouble | More trouble |
| Carbon formed | More | Less |
| Relative volume of air required per gallon | 1.04 | 1.00 |
| Relative volume of explosive gases produced per gallon | .92 | 1.00 |
| Temperature of explosion | Higher | Lower |
| Rapidity of explosive force | Less sudden | More sudden |

Benzol is most satisfactory if used mixed with gasoline or alcohol, preferably the latter.

# Possible Savings in Gasoline

The Bureau of Mines estimates that the following savings can be effected daily:

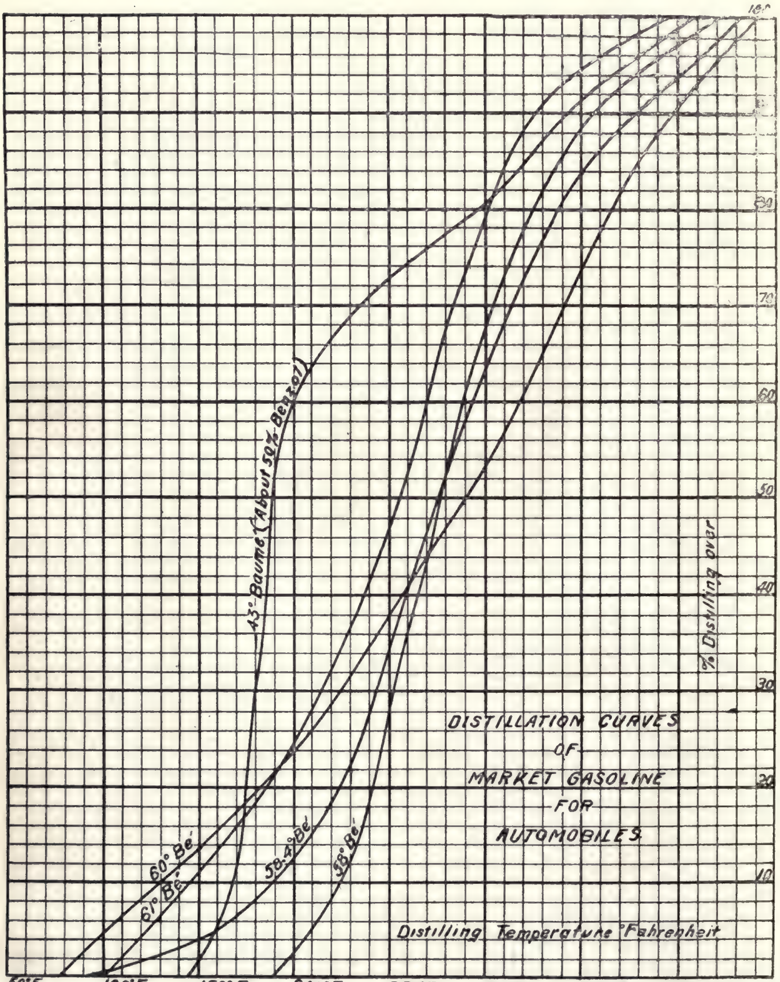
| | Gallons |
|---|---|
| Tank wagon losses | 7,200 |
| Leaky carburetors, average 1/17th of a pint per car | 31,400 |
| Poorly adjusted carburetors, ½ pint per car | 240,000 |
| Motors running idle, ¼ pint per car | 150,000 |
| Wasted in garages, 10 pints per day | 67,000 |
| Saved by using kerosene in garages | 108,000 |
| Needless use of passenger cars, 1¾ pints per car | 897,400 |

This makes a total of 1,500,000 gallons a day, or 561,000,000 gallons a year, whereas our war needs are 350,000,000 gallons a year, or less than two-thirds of what may be considered as wasted at the present time.

## SUGGESTIONS TO GASOLINE USERS.

The following important suggestions for avoiding waste will not only save gasoline, but users of motor vehicles will be benefitted personally and individually through more efficient and more economical operation of cars:

1. Store gasoline in underground steel tanks. Use wheeled steel tanks with measuring pump and hose. They prevent loss by fire, evaporation and spilling.
2. Don't spill or expose gasoline to air—it evaporates rapidly and is dangerous.
3. Don't use gasoline for cleaning and washing—use kerosene or other materials to cut grease.
4. Stop all gasoline leakages. Form habit of shutting off gas at tank or feed pipe.
5. Adjust brake bands so they do not drag. See that all bearings run freely.
6. Don't let engine run when car is standing. It is good for starter battery to be used frequently.
7. Have carburetors adjusted at service stations of carburetor or automobile companies—they will make adjustments without charge.
8. Keep needle valve clean and adjust carburetor (while engine is hot) to use as lean mixture as possible. A rich mixture fouls the engine and is wasteful.
9. Pre-heat air entering carburetor and keep radiator covered in cold weather—this will insure better vaporization.
10. See that spark is timed correctly with engine and drive with spark full advanced—a late spark increases gas consumption.
11. Have a hot spark, keep plugs clean and spark points properly adjusted.
12. Avoid high speed. The average car is most economical at 15 to 25 miles an hour.
13. Don't accelerate and stop quickly—it wastes gas and wears out tires. Stop engine and coast long hills.
14. Cut down aimless and needless use of cars. Do a number of errands in one trip.
15. Know your mileage per gallon. Fill tank full and divide odometer mileage by gallons consumed.



DISTILLATION CURVES OF MARKET GASOLINE FOR AUTOMOBILES
43° Baume (About 50% Benzol)
60° Bé
61° Bé
58.4° Bé
58° Bé
% Distilling over
Distilling Temperature °Fahrenheit
50°F
100°F
150°F
200°F
250°F
300°F
350°F
400°F
450°F
10
20
30
40
50
60
70

# Kerosene, Coal Oil, Illuminating Oils

Kerosene in a general way may be defined as that fraction of crude petroleum or oil made by the pyrogenic decomposition of shales or coal and it distills at a temperature of from 302°F to 572°F (150-300°C) and contains no gasoline or residuum. Its flash point is always greater than 100°F and usually greater than 120°F. Its color may be standard white, prime white, superfine white or water white. Its gravity ranges from 31 to 48° Baume'. Typical kerosene has a gravity of 41 to 42°Be'. Sulphur is usually almost completely absent from kerosene, being less than 0.03%. It consists chiefly of the paraffin series, particularly when the gravity is greater than 38. The principal constituents are nonane, decane, undecane, duodecane, tridecane, tetradecane, pentadecane, hexadecane and heptadecane. With lower gravities it contains naphthenes and aromatic compounds. This is particularly true of Louisiana oils and California oils.

The quality of good kerosene has been found to be within the following limits:

1. Specific gravity shall be between 0.760-0.860 (54.2-32.8°Be').
2. Flash point shall be over 100°F by closed tester.
3. Color shall be water white, with no turbidity.
4. Cold test shall be below 10°F.
5. End point shall be below 600°F.
6. Sulphur shall be below 0.03%.
7. Acid shall be absent.
8. It should not lose more than 1% on treatment with 66° sulphuric acid.

The U. S. Government specifications for various illuminating oils are as follows:

### WATER WHITE KEROSENE.

**Flash.**—To be taken on the Tag closed cup A. S. T. M. standard, oil to be heated at the rate of 2°F per minute, test flame to be applied every 2 degrees commencing at 105°F.

**Color.**—To be determined on the Saybolt colorimeter or its equivalent.

**Sulphur.**—Test to be made by burning at least 2 grams of the oil in a small flask and absorbing the gases of combustion in a standard solution of sodium carbonate and titrating the excess of sodium carbonate with the standard solution of sulphuric acid.

**Floc.**—For making the test, take a hemispherical iron dish and place a small layer of sand in the bottom. Take a 500 cc Florence or Erlenmeyer flask and into it put 300 cc of the oil (after filtering if it contains suspended matter). Suspend a thermometer in the oil by means of a cork slotted on the side. Place flask containing the oil in the sand bath and heat bath so that the oil has reached a temperature of 240°F at the end of one hour. Hold oil at temperature of not less than 240F° nor more than 350°F for six hours. The oil may become discolored, but there should be no suspended matter formed in the oil. The flask should be given a slight rotary motion, and if there is a trace of "floc" it can be seen to rise from the center of the bottom.

**Distillation Test**—The oil shall all distill below temperature of 600°F. The test is made as described by the Bureau of Mines Technical Paper 166, using A. S. T. M. apparatus with wet bulb and total immersion thermometer.

**Cloud Test.**—For making test take a 4-ounce oil sample bottle and introduce therein 1½ ounces of the oil to be tested. Insert cork with cold test thermometer so that thermometer is suspended in the oil. Place bottle in a freezing mixture and cool to 0°F. Keep oil cooled to this temperature for 10 minutes. Bottle should be given a rotary motion occasionally so as not to supercool the sides. The oil should not be clouded from crystals of paraffin wax at the end of ten minutes.

**Reactions.**—Two ounces of the oil should be shaken with ½ ounce of warm neutral distilled water and allowed to cool and separate. The water when separated shall react neutral to methyl-orange and phenolphthalein.

**Burning Test.**—The oil must burn freely and steadily in a lamp fitted with a No. 1 sun hinge burner. It must give a good flame for a period of 18 hours without smoking or forming "ears" or "toadstools" on the wick. The chimney must be only slightly clouded or stained at the end of the test.

**Specification Summary.**—Oil must be free from water, glue and suspended matter.

**Flash.**—Not less than 115°F, Tag closed cup, A. S. T. M. standard.

**Color.**—To be 21 color on Saybolt colorimeter or its equivalent on a Lovibond tintometer, these being equal to color of a solution of potassium bichromate containing 0.0048 gram per liter.

**Sulphur.**—Not more than 0.06%.

**Floc.**—Oil to be free from floc.

**Distillation.**—Oil to distill below temperature of 600°F.

**Cloud Test.**—Oil should not show cloud at 0°F.

**Reaction.**—Must be neither acid nor alkaline.

**Burning Test.**—As stated above.

## KEROSENE FOR U. S. NAVY.

Water white kerosene for U. S. Navy use when specifically required for special fuel shall have a heating value of not less than 20,000 B. T. U. per pound.

When specifically provided for a representative sample of the oil delivered will be tested photometrically after burning for 1 hour in a lamp fitted with a No. 1 sun hinge burner. Five hours later another photometric test will be made to determine any change in intensity of the light. The maximum allowable loss shall be 5%. The flame shall show at least 6 candle power when compared photometrically with an incandescent lamp which has been standardized by the Bureau of Standards.

Otherwise specifications enumerated above apply for U. S. Navy kerosene.

## LONG-TIME BURNING OIL.

**Flash.**—To be taken on the Tag closed cup, A. S. T. M. standard. Oil to be heated at the rate of 2°F per minute. Test flame to be applied every 2°, commencing at 105°F.

**Color.**—To be determined on the Saybolt colorimeter or its equivalent.

**Floc.**—For making test take a hemispherical iron dish and place a small layer of sand in the bottom. Take a 500 cc Florence or Erlenmeyer flask and into it put 300 cc of the oil (after filtering if it contains suspended matter). Suspend a thermometer in the oil by means of a cork slotted on the side. Place flask containing the oil in the sand bath and heat bath so that the oil has reached a temperature of 240°F at the end of one hour. Hold oil at temperature of not less than 240°F nor more than 250°F for 6 hours. The oil may become

discolored, but there should be no suspended matter formed in the oil. The flask should be given a slight rotary motion, and if there is a trace of "floc" it can be seen to rise from the center of the bottom.

**Cloud Test.**—For making cloud test take a 4-ounce oil sample bottle and introduce therein 1½ ounces of the oil to be tested. Insert cork with cold test thermometer, so that thermometer is suspended in the oil. Place bottle in a freezing mixture and cool to zero degrees Fahr. Keep oil cooled to this temperature for 10 minutes. Bottle should be given a rotary motion occasionally so as not to supercool the sides. The oil should not be clouded from crystals of paraffin wax at the end of 10 minutes.

**Reaction.**—Two ounces of the oil should be shaken with ½ ounce of warm neutral distilled water and allowed to cool and separate. The water when separated shall react neutral to methyl-orange and phenolphthalein.

**Burning Test.**—This test will be made by introducing 25 fluid ounces of oil into the pot of a standard Railway Signal Association semaphore lamp, fitted with the purchaser's standard burner, chimney and wick. The wick shall be new and previously washed with redistilled ether and dried at room temperature, the lamp to be protected from the direct rays of the sun but may be burned either outdoors or in a well-ventilated room. During the first hour of the test the wick will be adjusted so as to produce a flame ⅞-inch high, measured from the top of the wick. The lamp shall burn continuously without re-adjusting the wick for 120 hours or until all of the oil is consumed.

The flame shall remain symmetrical and free from smoke throughout the test period.

The height of the flame at any time during the test shall be not less than three-quarters of an inch. The oil shall not produce any appreciable hard incrustation on the wick.

Oil must be free from water, glue and suspended matter.

**Flash.**—Not less than 115°F, Tag closed cup, A. S. T. M. standard.

**Color.**—Twenty-one color on Saybolt colorimeter or its equivalent on a Lovibond tintometer, these being equal to color of a solution of potassium bichromate containing .0048 gram per liter.

**Floc.**—Oil to be free from "floc."

**Cloud Test.**—Oil should not show cloud at 0°F. See Note 1 below.

**Reaction.**—Must be neither acid nor alkaline.

**Burning Test.**—As stated above.

**Note No. 1 Relative to Cloud Test.**—Temperature of 0°F can be varied either up or down to suit the climatic conditions in the territory in which the oil is to be used.

## LIGHT HOUSE OIL.

Oil for use by the Bureau of Light Houses shall be as described by the Department of Commerce, which specifications, etc., at the present time are as follows:

(1) The kerosene must have a flash point of not less than 140°F and fire point of not less than 160°F (Tag closed tester).

(2) The kerosene must contain no free acids or mineral salts. Litmus paper immersed in it for five hours must remain unchanged.

(3) One hundred grams of kerosene shaken with 40 grams of sulphuric acid (sp. gr. 1.73) must show little or no coloration).

(4) When distilled from a still so jacketed as not to allow of local heating at a rate of not over 10% in ten minutes the kerosene shall not distill below 350°F and 98% shall distill under 515°F, the temperature taken being that of the condensing vapor.

(5) When burned for 120 hours in a lens lantern supplied with a fifth order oil lamp, the kerosene must burn steadily and clearly without smoking with minimum incrustation of wick, slight discoloration of chimney and less than 10% loss of candle power. A lamp of this description will be loaned to successful bidder.

## 300 DEGREE MINERAL SEAL OIL.

**Flash.**—To be taken on the Cleveland open cup, oil to be heated at the rate of 7°F per minute, test flame to be applied every 5°, commencing at 210°F.

**Fire Test.**—After the flash point is obtained the oil shall be heated at the same rate (7° per minute), test flame to be applied every 5° after the flash point has been obtained.

**Color.**—To be determined on the Saybolt colorimeter or its equivalent.

**Floc.**—For making test take 500 cc Florence or Erlenmeyer flask and into it put 300 cc of oil (after filtering if it contains suspended matter). Oil to be heated at the rate of 10°F per minute to a temperature of 450°F and held at that temperature for 15 minutes. The oil shall show no floc or precipitate at that temperature or one hour after cooling.

**Cloud Test.**—For making this test take a 4-ounce oil sample bottle. Introduce therein 1½ ounces of oil to be tested. Insert cork with cold test thermometer so that bulb is slightly below the surface of the oil. Place bottle in a freezing mixture and cool oil to a temperature of 32°F Keep oil cooled to this temperature for 10 minutes. Bottle should be given a rotary motion occasionally so as not to supercool the sides. The oil should not become cloudy from crystals of paraffin wax at the end of 10 minutes.

**Reaction.**—Two ounces of the oil should be shaken with ½ ounce of warm neutral distilled water and allowed to cool and separate. Water when separated shall react neutral to methyl-orange and phenolphthalein.

**Burning Test.**—This test will be made by introducing 20 fluid ounces of oil into a lamp fitted with a dual burner No. 3, dual chimney and duplex wicks. The lamp used shall be such that the distance from the top of the wick tube to the bottom of the inside of font is not less than 6½ inches nor more than 7 inches. During the first hour of the test the wicks will be adjusted so as to produce a symmetrical flame approximately 1 inch high, measured from the top of the wicks. The lamp shall burn continuously without readjusting until all of the oil is consumed.

The flame shall remain symmetrical and free from smoke throughout the test period. The oil shall not produce any appreciable hard incrustation on the wick.

The oil must be free from water, flue and suspended matter.

**Flash.**—Not less than 250°F, Cleveland open cup.

**Fire.**—Not less than 300°F, Cleveland open cup.

**Color.**—To be not less than 16 color on Saybolt colorimeter or its equivalent on the Lovibond tintometer, these being equal to color of a solution of potassium bichromate containing 0.012 grams per liter.

**Floc.**—Oil to be free from "floc."

**Cloud Test.**—Oil should not show cloud at 32°F.

**Reaction.**—Must be neither acid nor alkaline.

**Burning Test.**—As stated above.

## SIGNAL OIL.

**Flash.**—To be taken on the Cleveland open cup. Oil to be heated at the rate of 7°F per minute and test flame to be applied every 5°, commencing at 210°F.

**Fire Test.**—After the flash point is obtained the oil shall be heated at the same rate (7° per minute) and test flame to be applied every 5° after flash point has been obtained.

**Cloud Test.**—For making test take a 4-ounce oil sample bottle and introduce therein 1½ ounces of oil to be tested. Insert cork with cold test thermometer so that bulb is slightly below the surface of the oil. Place the oil in a freezing mixture and cool to 32°F. Keep oil cooled to this temperature for 10 minutes. Bottle should be given a rotary motion occasionally so as not to supercool the sides. The oil should not become cloudy at the end of 10 minutes from crystals of paraffin wax or solid fats from the lard oil or sperm oil.

**Burning Test.**—This test is to be made in standard railway signal hand lantern, the burner of which is fitted with a 1-inch wick. The oil to be burned 24 hours without trimming or adjusting the wick, the pot of the lantern to be refilled if too small for a test of the duration named.

Oil must produce a satisfactory flame throughout the test period.

The oil must not produce an appreciable amount of hard incrustation on the wick.

The flame must stand all forms of railroad signaling in any kind of weather without being extinguished or smoking the globe.

**Appearance.**—The oil must be free from water, glue and suspended matter.

**Composition.**—To be 300° mineral seal oil as adopted by the Committee on Standardization of Petroleum Specifications, compounded with pure prime winter strained lard oil or sperm oil or compounded with a mixture of pure prime winter strained lard oil and sperm oil.

**Flash.**—Not less than 250°F, Cleveland open cup.

**Fire.**—Not less than 300°F, Cleveland open cup.

**Cloud Test.**—Oil should not show cloud at 32°F.

**Percentage of Fatty Oil.**—"A" grade must contain not less than 30% of fatty oil by volume.

"B" grade must contain not less than 22% of fatty oil by volume.

The "A" grade shall always be furnished unless "B" grade is specifically ordered.

**Free Fatty Acids.**—"A" grade must contain not over 0.60% free fatty acid calculated as oleic acid.

"B" grade must contain not over 0.45% free fatty acid calculated as oleic acid.

**Burning Test.**—As stated above.

**Gravity.**—It will be noted that there are not gravity specifications for any of the products mentioned above. It has been known for a number of years that the gravity of an oil, by itself, has no relation to the quality. Two oils may have exactly the same gravity and one might be an excellent oil while the other would be absolutely worthless. This difference in quality is due to the crude from which it has been made. Therefore no gravity was specified and the quality was left to be determined by other specifications.

**Flash.**—The Tag closed cup A. S. T. M. standard was adopted because it has been accepted by several societies and its measurements have been standardized.

**Color.**—The Saybolt colorimeter was adopted because most of the kerosene manufactured in this country is tested by this machine.

## GAS OIL.

Gas oil is that fraction of petroleum distillation coming off after the kerosene or other illuminating oil. It is usually a destructive distillation resulting in a distilled product carrying a considerable amount of olefins and a residue having a lower viscosity than would be the case without a partially destructive distillation. When it is desired to avoid a destructive distillation, steam may be used, giving an oil suitable for absorption purposes sometimes known as straw oil.

Gas oil is used for making gas and for carburetting coal gas or water gas. It is also used to make Blaugas, which is a prodnct liquified under a pressure of about 1,500 pounds. It is also used for Pintsche gas. A typical gas oil has the following properties:

| | |
|---|---|
| Specific gravity | 0.843 = 36.1°Be′ |
| Flash point | 90°C |
| Burning test | 116°C |
| Distillation test | |
| 0°C-150°C | 0.0% |
| 150°C-300°C | 44.0% |
| 300°C up | 55.3% |
| Coke | 0.7% |

## GAS OIL FOR DIESEL ENGINES (U. S. NAVY).

1. Flash point not lower than 150°F (Abel or Pennsky-Marten's closed cup).
2. Water and sediment—trace only.
3. Asphaltum—none.

**Bunker Oil "B".**—Specifications to be the same as for navy fuel oil except:

(c) Omit and substitute "The flash point shall not be lower than 150°F as a minimum (Abel or Pennsky-Marten's closed cup) or 175°F (Tagliabue open cup)."

(d) Omit and substitute "To have a minimum gravity of 15° Baume′."

(f) Omit.

Navy standard fuel oil only will be supplied to battleships, destroyers and other vessels subject to heavy forced draft conditions or required to run smokeless. It will also be supplied for cargo oil for all shipments abroad or to navy storage.

Bunker oil "A" will be used by other types of vessels requiring a light oil and by shore stations fitted with separate storage for yard use. It will not be used where Bunker oil "B" can be satisfactorily used.

Bunker oil "B" will be used by all transports and cargo vessels which can satisfactorily burn an oil not heavier than 15° Baume′.

The commander, Cruiser and Transport Force, or his representative and the District supervisor, Naval Overseas Transportation Service, shall determine the grade of oil to be used by vessels operating under their direction.

**STRAW OIL (U. S. BUREAU OF STANDARDS).**

The characteristics of a straw oil for absorption of light oils from gas as recommended by some operators and which are concurred in by the committee of coal-tar products are substantially as follows:

1. Specific gravity not less than 0.860 (34°Be′) at 15.5°C (60°F).
2. Flash point in open cup tester not less than 135°C (275°F).
3. Viscosity in Saybolt viscosimeter at 37.7°C (100°F) not more than 70 seconds.
4. The pour test shall not be over 1.1°C (30°F).
5. When 500 cc of the oil are distilled with steam at atmospheric pressure collecting 500 cc of condensed water, not over 5 cc of oil shall have distilled over.
6. The oil remaining after the steam distillation shall be poured into a 500 cc cylinder and shall show no permanent emulsion.
7. The oil shall not lose more than 10% by volume in washing with 2½ times its volume of 100% sulphuric acid when vigorously agitated with acid for five minutes and allowed to stand for two hours.

An additional set of specifications for wash oil which is used by one Government department is as follows:

Specific gravity shall not be greater than thirty-five and nine-tenths degrees (35.9°) Baume′ at 60°F, equivalent to specific gravity 0.844.

Viscosity shall not be more than 56 seconds in a Saybolt viscosimeter at 100° Fahrenheit.

The oil shall not thicken or cloud at 25°F in the cold test.

At least 95% of the oil shall separate as a clear layer within 10 minutes after 100 cubic centimeters of oil and 100 cubic centimeters of water have been shaken together vigorously for 20 seconds at a temperature of 70°F.

There shall not be more than 14% of loss in volume of oil when 1 volume of oil and 2½ volumes of 100% sulphuric acid are vigorously agitated for 5 minutes and allowed to settle for 2 hours.

The oil shall not begin to distill below 240°C.

**Quality of Absorption Oil for Extracting Gasoline from Natural Gas (Westcott "Casinghead Gasoline").**

| | |
|---|---|
| Gravity | 35.6° |
| Initial boiling point | 536°F |
| End point | 698°F |
| Fire test | 312.8°F |
| Saybolt viscosity @ 100°F | 40.5 |

**Distillation.**

| | |
|---|---|
| Initial | 273 °C |
| 5% | 295 °C |
| 10% | 300 °C |
| 20% | 305 °C |
| 30% | 308.6°C |
| 40% | 311 °C |
| 50% | 316 °C |
| 60% | 322 °C |
| 70% | 329 °C |
| 80% | 336.5°C |
| 90% | 360 °C |

# Kerosene Regulations (March 1919)

(By Dr. G. W. Gray.)

| State. | Tabulation of Essential Points in State Laws. | | | | |
|---|---|---|---|---|---|
| | Cup | Flash | Fire | Gravity | Distillation |
| Alabama | | | 120 | | No law |
| Arizona | | | | | |
| Arkansas | Open Tag | | 160 | | No law |
| California | | | | | |
| Colorado | Foster | 90 | | | |
| Connecticut | Open Tag | 110 | 140 | | |
| Delaware | Open Tag | | 115 | | |
| Florida | | | | | No law |
| Georgia | Elliott | 100 | | | |
| Idaho | Open Tag | | 120 | | |
| Illinois | Open Tag | | 150 | | |
| Indiana | Indiana | 120 | | 50-46 | |
| Iowa | Elliott | 100 | | | |
| Kansas | Foster | 110 | | | |
| Kentucky | Tag | | 130 | | |
| Louisiana | Tag | 125 | | | |
| Maine | Tag | | 120 | | |
| Maryland | | | | | No law |
| Massachusetts | Tag | 100 | 110 | | |
| Michigan | Foster | 120 | | | |
| Minnesota | Tag | | 120 | | |
| Mississippi | | | | | No law |
| Missouri | Tag | 120 | | 40 min. | 4% resid. at 570 |
| Montana | Foster | 110 | | | No law |
| Nebraska | Foster | 112 | | 42 min. | 7% resid. at 570 |
| Nevada | | | | | No law |
| New Hampshire | | 100 | 120 | | |
| New Jersey | Tag | 110 | | | |
| New Mexico | | | 120 | | |
| New York | Tag | 110 | 110 | | |
| North Carolina | Elliott | 100 | | | 6% resid. at 570* |
| North Dakota | Elliott | 100 | 125 | | 4% resid. at 570 6% max. at 310 |
| Ohio | Foster | 120 | | | |
| Oklahoma | Tag | 115 | | 40-48 | † |
| Oregon | | | | | No law |
| Pennsylvania | Tag | | 110 | | |
| Rhode Island | Tag | | 110 | | |
| South Carolina | Elliott | 100 | | | 6% res. at 570 |
| South Dakota | Elliott | 105 | | 47° Pa. crude<br>41° M-C crude | Not more than 10% at 300<br>Not more than 4% at 570 |
| Tennessee | Tag | 120 | | | |
| Texas | | | | | No law |
| Utah | Foster | 110 | | | |
| Vermont | Tag | | 110 | | |
| Virginia | | | | | No law |
| Washington | Tag elec. cup | | 120 | | |
| West Virginia | | | | | No law |
| Wisconsin | Tag | 105 | 120 | | |
| Wisconsin | Foster | 110 | | | 5% resid. at 572 |

*North Carolina—If oils are lighter than 47 gravity, then residue must not be more than 10 per cent.

†Oklahoma—Oils 40-48 gravity must be branded Good. Oils less than 40 or more than 48 must be branded Inferior.

# Specifications for Petroleum Products of the Kansas City Southern Railway Co.

**Material.**—The materials desired under this specification are the products of distillation and refining of petroleum, unmixed with any other substance, and conforming to the detailed specifications below.

### Illuminating Oils.

**General Requirements.**—These oils must be water white in color, and free from sulphur in any form. "Cracked" oils are not desired. Products having an offensive odor or containing any admixture of other oils will not be accepted. All samples must show a neutral or slightly alkaline reaction.

**Tests.**—One sample shall be taken from each carload or fraction thereof, and subjected to the following tests:

### Headlight or 150 Degree Oil.

Sample must not flash below a temperature of 130 degrees, or burn below a temperature of 150 degrees Fahrenheit, when heated at the rate of 2 degrees per minute. The test flame to be applied once every 5 degrees, beginning at 110. The above flash and fire tests will be made in the Tagliabue open cup tester.

Samples must remain clear and transparent when called to a temperature of 0 degrees and held there for ten minutes.

It must have a specific gravity of between 41 and 48 degrees Baume′.

### Mineral Seal or 300 Degree Oil.

Sample must not flash below a temperature of 245 degrees or burn below a temperature of 300 degrees Fahrenheit, when heated at rate of 5 degrees per minute. The test flame to be applied once every 5 degrees, beginning at 180. The above flash and fire tests will be made in the Tagliabue open cup tester.

Sample must remain clear and transparent when called to a temperature of 32 degrees Fahrenheit, and held there for ten minutes.

It must have a specific gravity of between 38 and 43 degrees Baume′.

### Gasoline.

**General Requirements.**—Gasoline shall be water white in color.

**Tests.**—A sample sufficiently large to provide for the following tests, taken at random, will represent the shipment:

1. Gasoline must not be heavier than specific gravity of 72 degrees Baume, but when specifically ordered stove gasoline may be furnished at specific gravity of 66 degrees Baume.

2. A portion of the sample must be entirely volatile at a temperature not exceeding 100 degrees Fahrenheit.

3. When blotting paper is moistened with a few drops of the sample it must evaporate entirely, leaving no greasy stain.

**Conditions.**—If any portion of an accepted shipment is subsequently found to be damaged, or otherwise inferior to the original sample, that portion will be returned to the shipper at his expense.

Any sample failing to meet all the requirements of this specification will be condemned, and the shipment represented by it will be returned to the manufacturers, they paying freight both ways.

# Pennsylvania Railroad Company

**No. 20-A.**

**SPECIFICATIONS FOR PETROLEUM PRODUCTS.**

1. Five different grades of Petroleum Products will be used. These will be purchased in amounts as the demands of the service indicate.

2. The materials desired under this specification are the products of the distillation and refining of petroleum unmixed with any other substances, and conforming to the detail specifications below. Products having a very offensive odor, or being mixed with other oils, will not be accepted.

3. Shipments must be made as soon as possible after the order is received. It will be observed that the detail specifications provide for a change of cold test and flashing point in some of the oils on May 1st and October 1st. Shipments reaching destination on or after these dates must conform to the specifications characteristic of these dates and will be rejected if they fail, unless it can be shown that they have been more than a week in transit. No preliminary examination of samples will be required, but a limited amount of special preliminary examinations will be made on the request of the Purchasing Agent for use of parties desiring the information. Definite printed methods for determining flashing and burning points, for making cold test and for taking gravity will be furnished if desired, and in case of dispute these methods must be used.

4. A shipment being received at any shops, one sample of not less than a pint must be taken from any barrel at random, for each shipment of a carload or less, and sent by R. R. S. to the Chemist, Altoona, Pa. This sample must be accompanied by a "Sample for Test" tag properly filled out, and must be sent in a proper can, enclosed in a "Sample for Test" box. In taking the sample, care must be exercised to prevent contaminating the sample with any other oil or any other substance, and a clean, dry can must always be used. This sample will represent the shipment. If it stands the tests, the shipment will be accepted, except as provided in Section 5. If the sample fails to stand the tests, the shipment will be rejected and returned to the shippers, who must pay return freight.

5. The examination of a shipment for oil that is cloudy from glue or suspended matter must be made by those by whom the oil is received. The examination applies especially to 150 degree and 399 degree Fire Test Oils. As this defect rarely characterizes all of the barrels of a shipment, it is obvious that the sample for test may fail to show it. Accordingly when any barrel or barrels in a shipment are found to be cloudy from glue or suspended matter, such barrels must be set aside and returned to the shipper, notwithstanding the Test Report has shown the shipment to be ready for use.

6. The following detail specifications will be enforced:

**150° Fire Test Oil.**

This grade of oil will not be accepted if sample from shipment:

1. Is not "water white" in color.
2. Flashes below 130° Fahrenheit.
3. Burns below 151° Fahrenheit.
4. Is cloudy or shipment has cloudy barrels when received, from the presence of glue or suspended matter.
5. Becomes opaque or shows cloud when the sample has been 10 minutes at a temperature of 0° Fahrenheit.

### 300° Fire Test Oil.

This grade of oil will not be accepted if sample from shipment:

1. Is not "water white" in color.
2. Flashes below 249° Fahrenheit.
3. Burns below 298° Fahrenheit.
4. Is cloudy or shipment has cloudy barrels when received, from the presence of glue or suspended matter.
5. Becomes opaque or shows cloud when the sample has been 10 minutes at a temperature of 32° Fahrenheit.
6. Shows precipitation when some of the sample is heated to 450° Fahrenheit.

The precipitation test is made by having about two fluid ounces of the oil in a six-ounce beaker, with a thermometer suspended in the oil, and then heating slowly until the thermometer shows the required temperature. The oil changes color but must show no precipitation.

### Paraffine and Neutral Oils.

These grades of oil will not be accepted if the sample from shipment:

1. Is so dark in color that printing with long primer type cannot be read with ordinary daylight through a layer of the oil ½ inch thick.
2. Flashes below 298° Fahrenheit.
3. Has a gravity at 60° Fahrenheit below 24° or above 35° Baume'.
4. From October 1st to May 1st has a cold test above 10° Fahrenheit, and from May 1st to October 1st has a cold test above 32° Fahrenheit.

The color test is made by having a layer of the oil of the prescribed thickness in a proper glass vessel, and then putting the printing on one side of the vessel and reading it through the layer of oil with the back of the observer toward the source of light.

### Well Oil.

This grade of oil will not be accepted if the sample from shipment:

1. Flashes, from May 1st to October 1st, below 298°F, or from October 1st to May 1st below 249°F.
2. Has a gravity at 60°F below 28° or above 31° Baume'.
3. From October 1st to May 1st has a cold test above 10°F, and from May 1st to October 1st has a cold test above 32°F.
4. Shows any precipitation when 5 cubic centimeters are mixed with 95 cubic centimeters of gasoline.

The precipitation test is to exclude tarry and suspended matter. It is made by putting 95 cc of 88 degree B. gasoline, which must not be above 80 degrees Fahrenheit in temperature, into a 100 cc graduate, then adding the prescribed amount of oil and shaking thoroughly. Allow to stand 10 minutes. With satisfactory oil no separated or precipitated material can be seen.

### 500° Fire Test Oil.

This grade of oil will not be accepted if sample from shipment:

1. Flashes below 494° Fahrenheit.
2. Shows precipitation with gasoline when tested as described for well oil.

# Lubricating Oil

The principal source of lubricating oil is petroleum, from which the lighter components (naphtha and kerosene) have been removed by distillation, the residue thus obtained being used directly as a lubricant or separated by distillation into various fractions. By removing some of the fractions, as well as by mixing others, a variety of products may be obtained with special properties (viscosity, flash point, cold test and specific gravity).

This is the principle on which the industry is based. The separate fractions are further refined to remove odor, resinous materials, etc., as well as to attain the desired lightness of color. This is accomplished by means of sulphuric acid, agitating with a stream of air, the acid being later removed by washing with alkali or water; the purification may also be brought about by filtration through fuller's earth (customary in the United States).

In Europe the oil is distilled with superheated steam, recently als with partial vacuum, direct firing being avoided to prevent decompo sition. The temperature of the superheated steam is kept somewha higher than that of the still. Commercially, the distillates are cool and separated according to specific gravity, flash point and viscosit

In the United States direct firing is much used in separating th crude oil fractions, thus increasing the yield of illuminating oils. T refining, however, is carried on with superheated steam.

### ECONOMY OF LUBRICATION.

The economical transmission of power is largely dependent upo the maximum reduction of friction.

The purpose of lubrication is to overcome friction in so far as possible and to prevent wear and deterioration of adjacent moving parts.

It is claimed that from 40% to 80% of all power produced by machinery is lost in friction, and a very considerable part of this is lost in avoidable friction due to improper lubrication.

### THEORY OF LUBRICATION.

A lubricant should prevent direct contact between the bearings and the moving parts of machinery, thus substituting for metallic friction and wear the much smaller internal friction of the lubricant. The more completely this result is attained under the conditions of temperature, speed and pressure, the more valuable the lubricant from a mechanical point of view. Whether the mechanically most efficient lubricant is the most economical depends somewhat on the ratio of efficiency, the amount used and the price of the material. Greases have a low mechanical efficiency compared with liquid oils, but from the point of economy and cleanliness they are far superior.

Only liquids with great tendency to adhere are suited for lubrication, since only these have the property to penetrate by capillarity where journal and bearings are the closest and where the danger of contact and wear is the greatest. The lubricating oils prevent direct contact of the metal surfaces because of their adhesion to these surfaces and because their viscosity keeps them from being squeezed out by the pressure on the bearing.

Experience has shown that the power to adhere to metals increases with the viscosity of the oil. Since the danger that an oil will be

pressed out increases with the pressure on the bearings, it is advisable for high pressures to use oils of considerable viscosity.

With low pressure and high speed there should be used a very mobile oil, with higher pressure and great velocity more viscous oils. If, for example, a spindle rotating with practically no pressure but very rapidly were lubricated with a very viscous oil, it would mean a ıvish waste of power. But to lubricate a transmission gear with a mobile oil would be a waste of lubricant, while the use of a heavy rease would be entirely suitable. In fact, the use of a solid lubricant, raphite, with heavy oils as a vehicle, has proven most desirable in the case of very heavy bearings and transmission gears with enormous pressures.

The oil should not lose its power of reducing friction by evaporation, gumming or by acting chemically on the metal of the bearings or journal.

The oil or grease should not solidify or greatly change its viscosity under conditions of use.

## PHYSICAL TESTS FOR LUBRICANTS.

1. Flash and burning points of lubricants are the respective tem-·atures at which the vapors arise in sufficient amount to ignite and burn continuously. They should be high enough to prevent any ıger of fire in using the oil and to be assured that a light oil has been added to a heavy oil to regulate viscosity. With the same osity asphaltic base oils (Texas, California and Mexico) have a ver flash point and a higher specific gravity than paraffin base oils ennsylvania and West Virginia).

2. Specific gravity is the relation of the weight of a given volume of oil to the weight of the same volume of water. The oil trade usually uses the Baume' scale of gravity, which is entirely arbitrary (see ables). The paraffin oils with the same viscosity are lighter (have a higher gravity—Baume') than the asphaltic or semi-asphaltic oil. Gravity is not a measure of the quality of a lubricating oil.

3. Viscosity is the most important property for lubrication. The viscosity is expressed in the terms of the Saybolt Universal Viscosimeter in this country, the Engler in Germany and the Redwood in England (see conversion factors). Paraffin oils lose their viscosity most readily in use in an explosion cylinder by reason of the greater ease in decomposing to lighter products than do asphaltic oils (see also cracked lubricating oils). They tend to be more viscous at higher temperatures than naphthene base oils (note).

4. Carbon. The fixed carbon is a most harmful property in lubricants for explosion motors, such as automobiles. High fixed carbon is found in poorly refined and blended oils. It is higher in asphaltic than in Pennsylvania or Mid-Continent oils with the same refining. Less carbon is present in light oils.

5. Cold test determines the lowest temperature at which the oil will pour. A low cold test is desirable for ease in circulating and handling in cold weather. A low cold test for motor oils indicates the absence of heavy ends that produce excessive carbon in the cylinder.

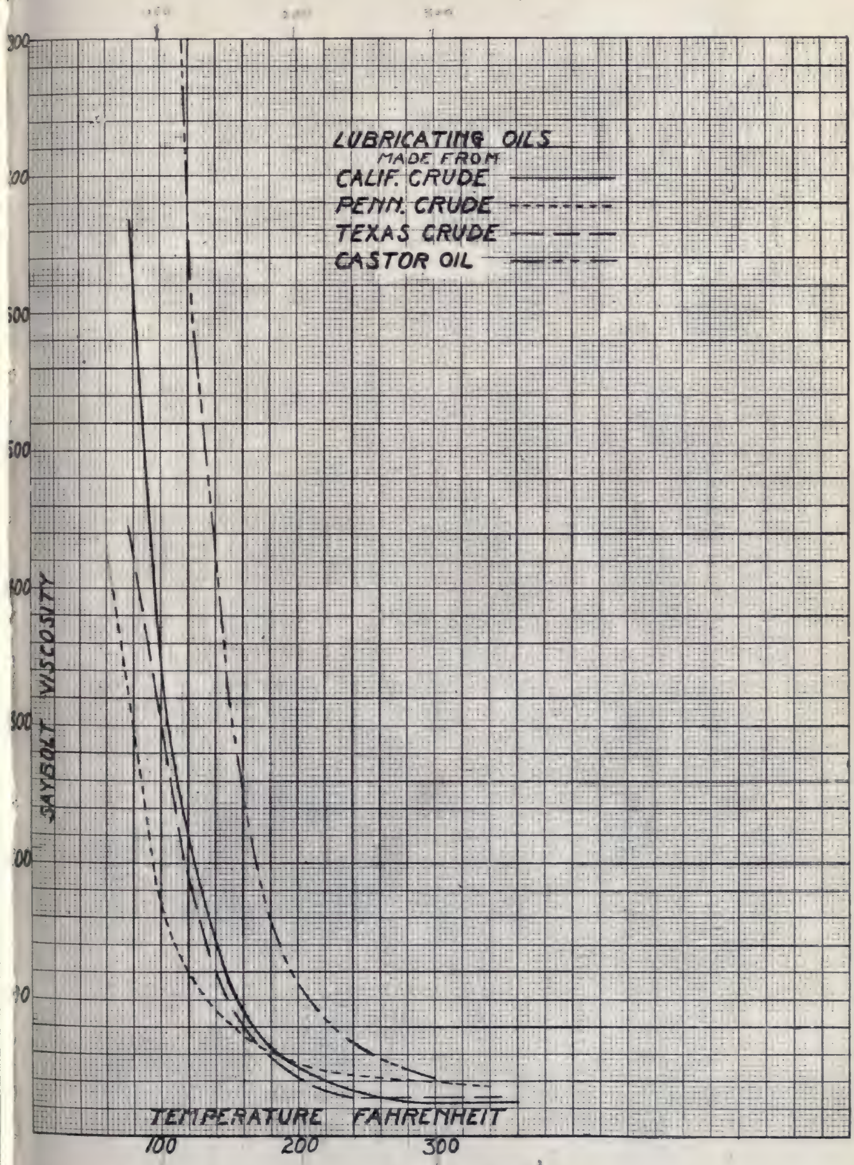
6. Color is not an index of the value of a lubricating oil. The lighter the color, other things being equal, the purer the oil.

7. Free acid should be, and usually is, absent. It is an indication of mineral acid that has not been neutralized and washed out in refining or of the presence of naphthenic acids.

The qualities of various lubricating oils are as follows:

| Viscosity at | Spindle | Light M'ch'n'y | Heavy M'ch'n'y | Auto-mobile | Engine | Steam Cylinder | Large Cylinder |
|---|---|---|---|---|---|---|---|
| 70°F. | 75-500 | 375-750 | 750-1875 | 470-1100 | 300-400 | ...... | 2800-4000 |
| 100°F. | .... | 180-220 | ....... | 160-400 | 130-150 | ...... | ........ |
| 122°F. | 75-90 | ..... | 110-280 | ...... | ...... | 1100 | 300-560 |
| 210°F. | .... | 40-50 | 45-60 | 40-55 | 44-47 | 120-150 | ........ |
| Flash point, °F Min. | 140 | 160 | 390 | 350 | 430 | 525 | 450 |
| Cold test, °F. | 10 | 5 | 10-40 | 10 | 25 | 45 | 40 |
| Gravity, Be'. | .... | ..... | ...... | 19-32 | 23-30 | 24-30 | ........ |

**Note.**—See Lubricating Engineer's Handbook, by J. R. Battle.


LUBRICATING OILS
MADE FROM
CALIF. CRUDE
PENN. CRUDE
TEXAS CRUDE
CASTOR OIL
SAYBOLT VISCOSITY
TEMPERATURE FAHRENHEIT
100
200
300

# Properties of Various Lubricants

PARTLY FROM "PETROLEUM."

| Trade Name or Classification | Machines and Conditions | Compound Per Cent | Baume Gravity Degrees | Saybolt Viscosity | Flash Point, F° | Fire Test, F° | Cold Test, F° |
|---|---|---|---|---|---|---|---|
| Cylinder oil | Steam engine; medium pressure; no superheater | Five per cent | 24.5-27 | 250 @ 212°F | 620 | 690 | 44 |
| Cylinder oil | Steam engine; high pressure; superheater | Straight mineral | 24.5 | 375 @ 212°F | 630 | 700 | .. |
| Cylinder oil | Steam engine; low pressure; no superheater | Five per cent | 25-26.0 | 130-150 @ 212°F | 550 | 600 | .. |
| Engine oil (heavy) | Heavy, hot bearings (extreme) | Straight mineral | 24.0 | 300-325 @ 100°F | 450 | 500 | 40 |
| Engine oil (heavy) | Heavy bearings; lower duty than above | Straight mineral | 24.5-25 | 250-280 @ 100°F | 400 | 450 | 35 |
| Engine oil (heavy compound) | Heavy bearings | 5% compound | 24-25 | 190-240 @ 100°F | 400 | 450 | 34-36 |
| Engine oil (medium) | Medium bearings; splash feed; pump circulation | Five per cent | 28-30 | 190-210 @ 100°F | 400 | 450 | 32 |
| Crankcase oil (heavy) | Steam engine; crankcase splash | Straight mineral | 26.5 | 150 @ 100°F | 440 | 490 | 30 |
| Crankcase oil (medium) | Steam engine; crankcase splash | Straight mineral | 28.0 | 120 @ 100°F | 400 | 450 | 28 |
| Crankcase oil (light) | Steam engine | Straight mineral | 32.0 | 75 @ 100°F | 395 | 445 | 26 |
| Turbine oil (heavy) | Steam turbine; large sizes | Straight mineral | 30.5 | 200 @ 100°F | 420 | 470 | 20 |
| Turbine oil (light) | Steam turbine; small sizes | Straight mineral | 32.0 | 150 @ 100°F | 395 | 445 | .. |
| Compressor oil (heavy) | Air compressor; single stage | Straight mineral | 26.5 | 115 @ 212°F | 500 | 550 | 55 |
| Compressor oil (light) | Air compressor; two-stage | Straight mineral | 30.0 | 200-380 @ 100°F | 420 | 470 | 20-25 |
| Ice machine | Ammonia compressor; two-stage | Straight mineral | 26-27 | 100 @ 70°F | 350-360 | 420 | 0-4 |
| Dynamo oil (heavy) | Large dynamos and motors; ring oil bearings | Straight mineral | 30.5 | 200 @ 100°F | 420 | 470 | 20 |
| Dynamo oil (medium) | Medium dynamos and motors; ring oil bearings | Straight mineral | 32.0 | 150 @ 100°F | 395 | 445 | .. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dynamo oil | Small motors, 1-32 to 5 HP; small ring oil bearings | Straight mineral | 27.5 | 90 @ 100°F | 345 | 400 | 18 |
| Black machine | Rough, slow speed bearings, lineshafts, crushers, etc.; cheap work | Straight mineral | 29.0 | 100 @ 70°F | 325 | 380 | 5-15 |
| General machine (heavy) | Hoists, elevators and general machinery, cool running | Straight mineral | 24.0 | 300 @ 100°F | 410 | 460 | 40 |
| General machine (medium) | Machine tools, print presses, large lathes, etc. | Straight mineral | 26.0 | 150 @ 100°F | 380 | 430 | 30 |
| Spindle oil | Light machines for spinning, automatics, etc. | Straight mineral | 30-35 | 60-150 @ 70°F | 340 | 390 | .. |
| Loom oil | Weaving machines; high speed medium weight machines | Straight mineral | 28.0 | 203 @ 100°F | 360 | 400 | .. |
| Gas engine oil | Gas engine cylinders and general splash and force feed lubrication of gasoline automobile and tractor engines | Straight mineral | 24.0 | 300-400 @ 212°F | 210-420 | 250-470 | .. |
| Motor (light) | Pa. Petroleum | 0.0012% C. Carbon | 30.5 | 185 @ 100°F | 415 | 475 | 20°F |
| Motor (medium) | Pa. Petroleum | 0.0031% C. Carbon | 30.0 | 285 @ 100°F | 435 | 500 | 25 |
| Motor (heavy) | Pa. Petroleum | 0.0060% C. Carbon | 29.5 | 475 @ 100°F | 440 | 500 | 35 |
| Cylinder oil | Ranger, Texas | 1.976 % C. Carbon | 22.6 | 135 @ 212°F | 485 | 550 | 50 |
| Motor oil | Texaco | 0.045 % C. Carbon | 20.0 | 652 @ 100°F | 380 | 450 | 10°F |

## EFFECT OF AIR-COOLED MOTOR (FRANKLIN) ON LUBRICATING OIL.

| | No. 1 | No. 2 |
|---|---|---|
| Crude from which manufactured | South Texas | Pennsylvania |
| Gravity before using | .934 = 20.0°Be' | .875 = 30.2°Be' |
| Gravity after using | .920 = 22.3°Be' | .860 = 33.0°Be' |
| Viscosity at 100° before use | 652 | 251 |
| Viscosity at 100° after use | 229 | 140 |
| Free carbon before use | 0.00 | 0.00 |
| Free carbon after use | 0.08% | 0.90% |
| Conradson carbon before use | 0.045% | 0.050% |
| Miles car run in use | 1000 | 600 |
| Lubricating oil consumed | 8% | 40% |

## EFFECT OF CRACKING ON THE LUBRICATING QUALITIES OF OIL.

In the cracking of petroleum by heat the paraffin hydrocarbons are most readily decomposed into lighter hydrocarbons. The lubricating hydrocarbons remaining in cracked oil are therefore not paraffin but consist chiefly of naphthenes and aromatics. In other words, cracking reduces the viscosity of heavy hydrocarbon oils based on the same gravity. This fact is set forth in the patent to Burton (U. S. No. 1,167,884, Jan. 11, 1916) as follows:

Lubricating fractions made from Mid-Continent Crude Petroleum

| Baume' Gravity | Viscosity at 100° (Saybolt Viscosimeter) |
|---|---|
| 25.0 | 235 |
| 26.0 | 190 |
| 26.0 | 165 |
| 26.5 | 145 |
| 27.5 | 100 |

Lubricating fractions made from California Crude Petroleum

| Baume' Gravity | Viscosity at 100° |
|---|---|
| 18.8 | 449 |
| 20.4 | 235 |
| 20.6 | 339 |
| 21.6 | 146 |
| 21.8 | 167 |
| 22.5 | 139 |

Lubricating fractions made from Cracked Petroleum Residua

| Baume' Gravity | Viscosity | Gravity | Viscosity |
|---|---|---|---|
| 28.9 | 36 | 15.2 | 88 |
| 26.5 | 38 | 15.0 | 89 |
| 23.8 | 42 | 14.7 | 97 |
| 21.5 | 45 | 14.1 | 105 |
| 21.1 | 51 | 13.2 | 110 |
| 20.2 | 52 | 13.0 | 116 |
| 18.7 | 58 | 12.0 | 158 |
| 17.8 | 62 | 10.8 | 198 |
| 17.2 | 65 | | |
| 16.7 | 66 | | |
| 15.8 | 76 | | |

## NATURAL HYDROCARBONS—VACUUM DISTILLED.

Table showing the properties of vacuum distilled hydrocarbons and atmospheric pressure forced fire distilled hydrocarbons of a heavy residuum from Mid-Continent oil.

| Fraction | Gravity | Viscosity | Sulphur |
|---|---|---|---|
| 0—10% | 0.868<br>31.3°Be′ | 46 | 0.39% |
| 10—20% | 0.877<br>29.6°Be′ | 60 | 0.35% |
| 20—30% | 0.895<br>26.4°Be′ | 143 | 0.43% |
| 30—40% | 0.909<br>24.0°Be′ | 293 | 0.53% |
| 40—50% | 0.920<br>22.1°Be′ | 740 | 0.76% |
| 50—60% | 0.920<br>22.1°Be′ | 745 | 0.68% |
| 60—70% | 0.920<br>22.1°Be′ | 1058 | 0.70% |
| 70—80% | 0.920<br>22.1°Be′ | 2600 | 0.56% |

## HYDROCARBONS FROM FORCED FIRE DISTILLATION OF SAME OIL.

| Fraction | Gravity | Viscosity |
|---|---|---|
| 0—10% | 0.864<br>32.1°Be′ | 51 |
| 10—20% | 0.877<br>29.6°Be′ | 69 |
| 20—30% | 0.888<br>27.6°Be′ | 109 |
| 30—40% | 0.893<br>26.7°Be′ | 141 |
| 40—50% | 0.894<br>26.6°Be′ | 141 |
| 50—60% | 0.887<br>27.0°Be′ | 106 |
| 60—70% | 0.878<br>29.4°Be′ | 75 |
| 70—80% | 0.877<br>29.6°Be′ | 69 |

## EFFECT OF TEMPERATURE ON VISCOSITY OF NATURAL MID-CONTINENT HEAVY OILS.

| | | Av'ge Mid-Continent Fuel Oil 26.8°Be′ | Heavy Kansas Crude 19.6°Be′ |
|---|---|---|---|
| 60°F | = | 294. | ..... |
| 70°F | = | 190. | 3360. |
| 100°F | = | 94. | 1250. |
| 120°F | = | 70. | 680. |
| 120°F | = | 55. | 328. |
| 212°F | = | 41. | 105. |

(Viscosity is expressed in terms of the Saybolt Universal)

## U. S. GOVERNMENT SPECIFICATIONS FOR LUBRICATING OILS

### LIBERTY AERO OIL.

### SPECIFICATION NO. 3,501.

1. This specification covers the requirements of the army in all purchases of oil to be used for the lubrication of stationary cylinder aircraft engines.

2. It is intended to use the name "Liberty Aero Oil" for all oils approved for the lubrication of these engines. On account of the differences in characteristics of the high and low specific gravity oils, this specification is drawn to cover both types of oil and to include products manufactured from crude petroleum oils from all fields. For the purposes of this specification oils are classified as follows:

### CLASSIFICATION.

3. High Specific Gravity Oils—This class includes all oils having a specific gravity above 0.9100 or below 24 degrees Baume' conversion by the Tagliabue Manual, 9th edition, or below 25.85 degrees Baume' conversion by the Bureau of Standards' conversion table, Circular No. 57) and having a pour test below 15 degrees Fahrenheit. (Tested by the method of the American Society for Testing Materials.)

4. Low Specific Gravity Oils—This class includes all oils having a specific gravity below 0.9100 (or above 24 degrees Baume' conversion by the Tagliabue Manual, 9th edition, or above 23.85 degrees Baume' conversion by the Bureau of Standards' conversion table, Circular No. 57) and having a pour test above 15 degrees Fahrenheit. (Tested by the method of the American Society for Testing Materials.)

### PHYSICAL PROPERTIES AND TESTS.

5. The oil must be made from pure, highly refined petroleum products, and must be suitable in every way for the entire lubrication of stationary cylinder aircraft engines operating under all conditions.

6. The oil must be neutral in action and must not show the presence of moisture, sulphonates, soap, resin or tarry constituents which would indicate adulteration or lack of proper refining.

7. Viscosity—The viscosity of the oil, when tested in a Saybolt Universal Viscosimeter at 212 degrees Fahrenheit, shall be as follows:

High specific gravity oil—70 seconds to 75 seconds.

Low specific gravity oil—85 seconds to 90 seconds.

8. Pour Test—The oil must pass the following pour test:

High specific gravity oil—not over 15 degrees Fahrenheit.

Low specific gravity oil—not over 40 degrees Fahrenheit.

9. Flash Point—The oil must have a flash point over 350 degrees Fahrenheit in a Cleveland open cup.

10. Carbon—The oil must not show a carbon residue of over 1.5 per cent by the Conradson method. The carbon shown must be loose and flaky and must break up easily in the crucible.

11. Emulsion Test—One ounce of oil shall be placed in a standard four-ounce sample bottle with one ounce of distilled water. The mixture shall be heated to a temperature of 180 degrees Fahrenheit, and then shaken vigorously for five minutes. After standing for one hour, the oil must be clear and of the same color as before the test. All of the water must have settled and appear only slightly cloudy.

12. All tests must be made in accordance with methods adopted by the American Society for Testing Materials. Detailed descriptions of the Conradson carbon test and the pour test have been reprinted in Army Specification No. 3,525 which will be furnished on application.

## MOTOR OIL FOR GASOLINE ENGINES.
## SPECIFICATION NO. 3,502.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

### GENERAL.

1. This specification covers the requirements of the Signal Corps for motor oil to be used for the lubrication of internal combustion engines other than airplant engines and motorcycle engines.

2. The oil shall be supplied in three grades—light, medium and heavy. The light oil shall be used where specially specified. The medium oil shall be for general use in winter and for use in new engines at all times. The heavy oil shall be for general use in summer and for use in old engines.

### PHYSICAL PROPERTIES AND TESTS.

3. The oil must be a refined and filtered mineral oil, or a mixture of such oils. It must be suitable in every way for the satisfactory lubrication of the internal combustion engines specified above.

4. Viscosity—The viscosity of the three grades of oil, when tested in a Saybolt viscosimeter at 100 degrees F., must be within the following limits:

Light oil—270 seconds to 230 seconds.
Medium oil—270 seconds to 330 seconds.
Heavy oil—470 seconds to 530 seconds.

5. Carbon—The carbon residue, determined by the Conradson method, must be as follows:

Light oil—not more than 0.2 per cent.
Medium oil—not more than 0.4 per cent.
Heavy oil—not more than 0.6 per cent.

6. Pour Test—One ounce of the oil must not congeal in a standard 4-ounce sample bottle when exposed to the following temperatures:

Light oil—25 degrees F.
Medium oil—30 degrees F.
Heavy oil—40 degrees F.

7. All tests shall be made in accordance with methods adopted by the American Society for Testing Materials. Detailed descriptions of the Conradson carbon test and the pour test have been reprinted in army specification No. 3,525, which will be furnished on application.

## AIRPLANE MACHINE GUN OIL.
## SPECIFICATION NO. 3,503.

### GENERAL.

1. This specification covers the requirements of the Army for gun oil for the lubrication of machine guns on airplanes and for gun oil for cleaning and oiling machine guns and small arms.

### PHYSICAL PROPERTIES AND TESTS.

2. The oil must be a highly refined, highly filtered straight-run mineral oil, suitable in every way for the uses specified in paragraph 1. It must be a pure petroleum product, without the addition of

vegetable or animal oils or fats of any kind, and must contain no moisture.

3. The oil must be free from acids and from any material which might gum or corrode metals under any conditions.

4. Viscosity—The viscosity, when the oil is tested in a Saybolt universal viscosimeter at 100 degrees F., shall be as follows:

Seventy seconds to 95 seconds.

5. Acidity—The acidity of the oil must not be more than 0.03 per cent calculated as $SO_3$.

6. Carbon—The carbon residue must not be more than 0.003 per cent when determined by the Conradson method.

7. Pour Test—One ounce of the oil must not congeal in a standard 4-ounce bottle at 45 degrees below zero F.

8. All tests must be made in accordance with methods adopted by the American Society for Testing Materials. Detailed descriptions of the Conradson carbon test and the pour test have been reprinted in army specification No. 3,525, which will be furnished on application.

## TRANSMISSION LUBRICANT.

### SPECIFICATION NO. 3,504.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

### GENERAL.

1. This specification covers the requirements of the Army for a very adhesive mineral oil, which must be suitable in every way for the lubrication of transmission gears and bearings, differential gears, warm drives, winch drives and roller and ball bearings used in connection with such parts of the equipment of motor vehicles.

### CHARACTERISTICS.

2. The lubricant must be a petroleum product only, without the addition of vegetable or animal oils or products, or residues or fats of any kind. It must be entirely free from fillers such as talc, resin, tar and all materials of every nature not related to the original product.

#### Physical Properties.

3. Viscosity.—The viscosity must be within the following limits when the lubricant is tested in a Saybolt universal viscosimeter at 212 degrees F.: 195 seconds to 220 seconds.

4. Adhesiveness.—The adhesiveness of the lubricant is one of the most essential qualities. As there is no satisfactory laboratory method for its determination, the adhesiveness will be determined by applying the lubricant to a set of gears operating under practical conditions and comparing the effect produced by the lubricant with the effect produced by a standard sample of army specifications No. 10 under the same conditions.

## NON-FLUID TRANSMISSION LUBRICANT.

### Specification No. 3,505.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

**General.**

1. This specification covers the requirements of the Army for purchases of non-fluid transmission lubricant to be used for the axles and transmissions of motor trucks.

**Physical Properties and Tests.**

2. The lubricant shall be composed of calcium soap and mineral oil manufactured in accordance with the best commercial process. It must have a consistency similar to that known to the trade as "No. 00 grease."

3. The lubricant must be a boiled grease containing not less than 1 nor more than 1½ per cent of moisture in the finished product.

4. Mineral Oil Base.—The mineral oil used in reducing the soaps, when tested in a Saybolt universal viscosimeter at 100 degrees F., must show a viscosity of not less than 180 seconds.

5. Saponifiable Fat Base.—Not more than 10 per cent of either pure tallow oil, neatsfoot oil, lard oil or horse oil, singly or in combination, shall be used as a fat base.

6. Acidity.—The lubricant must not attack a sheet of polished copper within a period of 48 hours.

7. Heat Test.—Two ounces of the grease shall be heated to 212 degrees F., or until the entire mass becomes liquid, and then allowed to cool. The soaps must not separate from the oils during this test, and the grease must return to its original consistency.

8. Fillers.—The grease shall contain no fillers, such as resin, resinous oils, soapstone, wax, talc, powdered mica, lamp black, sulphur, clay, asbestos or any other artificial thickening.

## MEDIUM CUP GREASE.

**Specification No. 3,506.**

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

**General.**

1. This specification covers the requirements of the Army for a medium cup grease to be used for the lubrication of such parts of motor equipment and other machinery as are lubricated by means of compression cups.

2. The grease must be a well manufactured product, composed of calcium soap and mineral oil.

**Physical Properties and Tests.**

3. Mineral Oil Base.—The mineral oil used in reducing the soaps must show a viscosity of at least 180 seconds when tested in Saybolt universal viscosimeter at 100 degrees F.

4. Saponifiable Fat Base.—The grease must have a fat base of 15 to 20 per cent of either pure tallow oil, neatsfoot oil, lard oil or horse oil, used singly or in combination.

5. Consistency.—The grease must be a medium cup grease similar in consistency to that known to the trade as "No. 3 cup grease."

6. Moisture.—The grease must be a boiled grease containing not less than 1 nor more than 3 per cent of moisture when finished.

7. Acidity.—The grease must not attack a sheet of polished copper within a period of 48 hours.

8. Ash.—The ash shall not be greater than 2 per cent.

9. Heat Test.—Two ounces of the grease shall be heated to 212 degrees F., or until the entire mass becomes liquid and then allowed

to cool. The soaps must not separate from the oils during this test, and the grease must return to its original consistency.

10. Fillers.—The grease must contain no fillers, such as resin, resinous oils, soapstone, wax, talc, powdered mica, lamp black, sulphur, clay, asbestos or any other filler or artificial thickening.

## GUN OIL.

### Specification No. 3,507.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

### General.

1. This specification covers the requirements of the Army for gun oil to be used for the following purposes and where airplane machine gun oil (Specification No. 3,503) is not required:

For cleaning and oiling guns and small arms.

For filling recoil cylinders of artillery and naval guns.

For oil switches and oil current breakers.

For transformers up to 6,600 volts.

For lubrication of the compressor and expander cylinders of ice machines.

For lubrication of pneumatic tools.

For hydraulic systems.

### Physical Properties and Tests.

2. The oil must be a straight-run highly refined and highly filtered mineral oil, suitable in every way for the uses listed in paragraph 1.

3. The oil must be a petroleum product only, free from vegetable or animal oils or fats of any kind and entirely free from moisture.

4. Specific Gravity.—The oil must have a Baume' gravity of not more than 23 degrees at a temperature of 60 degrees F.

5. Viscosity.—The viscosity must be within the following limits when the oil is tested in a Saybolt universal viscosimeter at 100 degrees F.: 95 seconds to 105 seconds.

6. Flash Point.—The flash point of the oil must not be less than 300 degrees F. in a Cleveland open cup.

7. Pour Test.—One ounce of the oil must not congeal in a standard sample bottle at 5 degrees below zero F.

8. Carbon.—The carbon residue must not be more than 0.003 per cent by the Conradson method.

9. Acidity.—The oil must not show an acid reaction of more than 0.03 per cent, calculated at $SO_3$, and must not gum or corrode metals under any conditions.

10. All tests must be made in accordance with methods adopted by the American Society for Testing Materials. Detailed descriptions of the Conradson carbon test and the pour test have been reprinted in Army Specification No. 3,525, which will be furnished on application.

## GEAR, CHAIN, WIRE ROPE LUBRICANT.

### Specification No. 3,508.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

**General.**

1. This specification covers the requirements of the Army for a very adhesive, heavy-bodied, straight mineral oil, which must be suitable in every way for the following uses:

For the lubrication and protection of chains, wire ropes and gears of cranes, dredges, steam shovels and all other heavy equipment.

For the lubrication and protection of the gears and ropes of balloon hoists.

For swabbing the wires and cables of airplanes and seaplanes.

For slushing and protecting the bright and exposed metal parts of guns, machines and automobiles during storage or overseas shipment. When used for this purpose the lubricant shall be mixed with an equal amount of kerosene, so that it may be applied with a brush.

2. Kerosene may be used to remove this lubricant from the equipment.

**Physical Properties and Tests.**

3. The quality of the lubricant must be equal to or better than that of a standard sample of No. 1 wire rope lubricant, sample of which will be furnished by the Quartermaster-General, Fuel and Forage Division, Washington, D. C.

4. The lubricant must be a petroleum product only, free from vegetable or animal oils or products or residues or fats of any kind. It must be entirely free from fillers, such as talc, resin, tar and all materials of every nature not related to the original product.

5. Viscosity.—The viscosity must be within the following limits when the lubricant is tested in a Saybolt universal viscosimeter at 212 degrees F.: 900 seconds to 1,100 seconds.

6. Adhesiveness.—The adhesiveness of the lubricant is one of its most essential qualities. As there is no satisfactory laboratory method for the determination of this quality, the adhesiveness will be determined by applying the lubricant to a set of gears operating under practical conditions and comparing the effect produced with that produced by a standard sample of No. 1 wire rope lubricant mentioned above under the same conditions.

7. Corrosion Test.—When applied to a plate of polished steel the lubricant must protect the steel for a period of thirty days from chemical vapors, from the action of salt or fresh water and from the action of water containing from 10 to 25 per cent of sulphuric acid.

For the purposes of these tests the water and solutions shall be held at a temperature of 60 degrees F.

**Drying Test.**

8. When the lubricant is applied to a wire rope that has not been oiled with any other material, it must not crack, peel or chip after exposure to low atmospheric temperatures for sixty days.

**Penetration Test.**

9. When applied hot to the outside of a 1-inch wire rope that has not been oiled with any other material the lubricant must penetrate to and be absorbed by the fiber core, and at the end of sixty days, when the rope is put under strain, the oil must be forced out of the core between the wires of the strand.

## MINERAL CYLINDER OIL.
### Specification No. 3,509.

This specification has been approved and adopted by the Ordnance Department, the Quartermaster Corps, the Engineer Corps, the Medical Corps and the Signal Corps, United States Army.

### General.

1. This specification covers the requirements of the army for mineral cylinder oil known to the trade as "600 Steam Refined Cylinder Oil," to be used for steam engine lubrication, where a mineral oil is required, also as a stock oil for compounding, and as a light transmission lubricant for motor vehicles.

### Physical Properties and Tests.

2. The oil must be a well refined, unfiltered oil, without compounding of any nature. It must be free from moisture, dirt and all foreign matter.

3. Viscosity.—The viscosity must be within the following limits when the lubricant is tested in a Saybolt universal viscosimeter at 212 degrees F.: 135 seconds to 165 seconds.

4. Flash Point.—The flash point of oil must be more than 475 degrees Fahrenheit in a Cleveland open cup.

5. Pour Test.—One ounce of the oil, in a standard 4-ounce sample bottle, must not congeal at 45 degrees F.

6. All tests must be made in accordance with methods adopted by the American Society for Testing Materials. Detailed description of the pour test has been reprinted in Army Specification No. 3,525, which will be furnished on application.

## COMPOUND CYLINDER OIL.
### Specification No. 3,510.

This specification has been approved and adopted by the Signal Corps, Quartermaster Corps and the Engineer Corps, United States Army.

### General.

1. This specification covers the requirements of the Army for compound cylinder oil to be used for the lubrication of steam cylinders of engines and pumps, where a compounded oil is required.

### Physical Properties and Tests.

2. The oil must be a well refined, clean, mineral cylinder oil, known to the trade as "600 Steam Refined Cylinder Oil." It must be compounded with from 5 to 10 per cent of tallow oil. The finished oil must be free from moisture, dirt and all foreign matter.

3. Viscosity.—The viscosity, when the oil is tested in a Saybolt universal viscosimeter at 212 degrees F. must be as follows: 135 seconds to 150 seconds.

4. Flash Point.—The flash point of the oil must be over 475 degrees F. in a Cleveland open cup.

5. Pour Test.—One ounce of the oil must not congeal in a standard 4-ounce sample bottle at 50 degrees F.

6. All tests shall be made in accordance with methods adopted by the American Society for Testing Materials. Detailed description of the pour test has been reprinted in Army Specification No. 3,525, which will be furnished on application.

# Lubricating Refinery Terminology

**Aeroplane Oil.**—This is oil used for aeroplanes, typical of which is the Liberty aeroplane oil under Specification No. 3501, page 168. It is frequently a light colored, straight production, viscous neutral oil.

**Automobile Oils** are usually viscous neutral oils with a flash point above 400°F and a Saybolt viscosity over 145 at 70°F.

**Axle Oil** is a natural black lubricating oil, commonly summer black oil of a 500°F to 550°F fire test. It is used also as a tempering oil.

**Bolt Oil** is a viscous neutral oil with a gravity of about 30° Baume', viscosity of about 220, used for thread cutting.

**Brick Oil** is a light non-viscous neutral oil with a gravity about 34° Baume', a flash point of about 340°F, viscosity of about 80 at 70°F. It is also known in terms of **Paint Oil.**

**Car Oil** is the same as axle oil and summer black oil.

**Castor Oil** is oil from castor beans; has a specific gravity of .965 Baume', gravity of 15°, cold test of 5°F, viscosity on the Saybolt universal viscosimeter at 100°F of 1200

| | |
|---|---|
| 125°F | 600 |
| 150°F | 300 |
| 175°F | 175 |
| 200°F | 110 |
| 250°F | 60 |
| 300°F | 40 |

**Claroline Oil** has a viscosity of 4.4° Engler at 70°F. It is essentially the same as straw oil or absorption oil.

**Condenser, Compounded** and **Blown Oils** are mixtures of mineral lubricating oils with seed oil, the seed oil usually being blown to increase the viscosity.

**Cylinder Oil** or **Cylinder Stock** is the residue obtained from distilling special grades of light crude oils with a very large amount of steam, avoiding cracking as much as possible, and from which the wax distillate has been removed. Cylinder oil varies in gravity from 20° to 27°Be', flash point 475°F to 650°F, viscosity at 210 Saybolt, 100 to 350, cold test 30 to 60°F. They usually are not filtered, but may be refined by filtering through Fuller's earth or bone black.

**Cove Oil** is 36° gravity mineral oil compounded with seed oil.

**Cream Separator Oils** are non-viscous oils of about 30 to 34° gravity, 70 to 200 viscosity at 70°F.

**Cup Greases** are mixtures of petroleum oil and lime soap with or without rosin oil.

**Dynamo Oil** is a viscous neutral oil, gravity 30-32°Be', flash point 400-425°F, fire test 450-500°F, cold test 15-30°F, Saybolt viscosity 140-225.

**Engine Oil** is a variable quality of lubricating oil, a common type of which has a Saybolt viscosity of 180-300, cold test 20-30°F, flash point of 400°F, gravity of 29°Be'.

**Floor Oil** is a light non-viscous neutral oil.

**Gear Case Oil** is a steam refined cylinder oil with a gravity of about 25°Be', flash point 600°F, cold test of 30°F, Saybolt viscosity at 210°F of 240.

**Hammer Oil** is a steam cylinder oil with a viscosity of about 220.

**Harness Oil** is a compounded oil containing petrolatum, leather oil and wax and some fatty oils.

**Knitting Machine Oil** is a spindle oil of 70-200 viscosity at 70°F.

**Leather Oil** is a non-viscous neutral oil of low viscosity.

**Machine Oil** is made in various grades with viscosities of 290 to 800 Saybolt at 70°F. It is usually a red oil with a cold test of about 30°F.

**Motor-Cycle Oil** is a high viscosity lubricating oil similar to aeroplane oil.

**Neutral Oils** are oils obtained from pressed distillates.

**Non-Viscous Neutral Oils** are oils having a viscosity below 135 Saybolt at 100°F.

**Viscous Neutral Oils** are oils having a viscosity above 135 at 100°F.

**Mineral Seal Oils** are heavy burning oils obtained in the distillation for cylinder stock.

**Oil Dag** is a compound of deflocculated graphite suspended in petroleum lubricating oil covered by U. S. Patent No. 911,358 by Acheson.

**Paraffin Oil** is the wax-free oil obtained by pressing wax distillate.

**Paraffin Scale** is crude wax.

**Sweated Wax** is crude wax freed from oil.

**Refined Wax** is sweated wax which has been filtered and decolorized with Fuller's earth.

**Pressed Distillate** or **Pressed Oil** is the oil after the wax distill[illegible] has been refrigerated and the wax removed from it.

**Petroleum Coke** is the residue in coking or tar stills and usu[illegible] constitutes about 5% of the crude oil. Mid-Continent crude leave[illegible] residue ordinarily about 6 inches thick in the still, and Mexican cru[illegible] petroleum leaves a residue about 30 inches thick in the bottom of th[illegible] still.

**Roll Oil** for tin, copper and brass rolls has the same qualities a[illegible] engine oil.

**Sewing Machine Oil** is light neutral oil with a viscosity of 75 at 70°F, cold test 20°F or below, fire test 400°F, flash point 340°F, a gravity of 34.5°Be′.

**Spindle Oils** are the lighter lubricating oils usually of a gravity of 25-35°Be′, flash point 300-450°F, viscosity 40-400 at 70°F, cold test 0°-40°F, a colorless to dark red.

**Stitching Oil** is a light non-viscous neutral oil used for stitching shoes.

**Summer Black Oil** is a black lubricating oil of about 500-600 fire test and is used for tempering and for concrete waterproofing.

**Tar Stills** or **Coking Stills** are large oil stills in which heavy portions of crude petroleum are distilled by intense firing until nothing but coke remains in the bottom of the still. This sort of distillation is desirable to produce a wax distillate from which the crystalline wax may be easily filtered.

**Tower Stills** are types of crude oil stills used to prevent the accumulation of coke in the still and does not subject the oil to as much cracking in the still as in the ordinary method.

**Tempering Oil** is a viscous neutral oil, frequently the same as hammer oil and summer black oil.

**Thread Cutting Oil** is viscous neutral oil of the quality of engine oil. It is sometimes compounded with 20-40% of lard oil.

**Thickened Oils** are mineral oils in which the viscosity is increased by the addition of unvulcanized rubber, aluminum soap or blown vegetable oil.

**Transformer Oils** are oils free from acid with flash point over 300°F and viscosity of about 100.

**Transmission Oil** is steam cylinder oil of a viscosity of 245 at 210°F.

**Turbine Oil** is a non-emulsifying oil of about 150 viscosity at 70°F and a flash point of about 420°F.

**Vaseline** is a semi-solid paraffin oil or wax composed of sufficient varieties of petroleum hydrocarbons to give an indistinct melting point.

**Watch Oil** is usually a non-petroleum oil and is ordinarily Dolphin oil.

**Winter Oil** is an engine oil having a cold test of —20°F.

**Wax Distillate** is the distillate coming from the coking stills and containing wax in crystalline form which immediately follows the gas oil.

**Wool Oil** is a sun bleached neutral oil sometimes compounded with lard oil and with a viscosity of 140-160 Saybolt, gravity of about 32°Be' and flash point of 375°F.

## PETROLATUM LIQUIDUM, U. S. P.
### Liquid Petrolatum.
### Petrolat. Liq.—Liquid Paraffin, Mineral Oil.

A mixture of liquid hydrocarbons obtained from petroleum. Preserve it in well closed containers, protected from light.

Heavy Liquid Petrolatum.—Heavy Liquid Petrolatum has a viscosity of not less than 3.1 when determined by the test given below.

Light Liquid Petrolatum.—Light Liquid Petrolatum has a viscosity of not more than 3 when determined by the test given below and vaporizes freely.

Each variety conforms to the following description and tests:

Specific gravity for Liquid Petrolatum, 0.828 to 0.905 at 25°C.

A colorless, transparent, oil liquid, free or nearly free from fluorescence, odorless and tasteless when cold and possessing not more than a faint petroleum odor when heated.

When cooled to 10°C Liquid Petrolatum does not become more than opalescent (solid paraffins).

Insoluble in water or alcohol; soluble in ether, chloroform, petroleum benzin or in fixed or volatile oils. Camphor, menthol, thymol and many similar substances are dissolved by Liquid Petrolatum.

Boil 10 mils. of Liquid Petrolatum with an equal volume of alcohol, the alcoholic liquid is not acid to litmus (acids).

Introduce into a glass-stoppered cylinder which has been previously rinsed with sulphuric acid 5 mils. of Liquid Petrolatum and 5 mils. of colorless sulphuric acid, heat in a water bath during 10 minutes, shaking well at intervals of 30 seconds; the oil remains unchanged in color and the acid does not become darker than pale amber (carbonized impurities).

Prepare a clear, colorless saturated solution of lead oxide in an aqueous solution of sodium hydroxide (1 in 5) and mix 2 drops of

this solution with 4 mils. of Liquid Petrolatum and 2 mils. of dehydrated alcohol; the mixture does not darken after heating for 10 minutes at 70°C and cooling (sulphur compounds).

Viscosity.—Make a permanent mark about 2 cm. below the bulb of a 50 mil. pipet of the usual type and note the time in seconds required at 25°C for the level of distilled water to fall from the upper to the lower mark as the liquid flows from the pipet. The time should not be less than 25 seconds nor more than 30 seconds for the pipet selected.

Draw the Liquid Petrolatum to be tested into this pipet, which should be clean and dry, and note the time in seconds required at 25°C for its level to fall from the same upper to the lower mark as used for the water. Divide the number of seconds thus noted by the number of seconds required for water to fall from the upper to the lower mark as above determined. The quotient indicates the viscosity. Distilled water at 25°C is taken as 1.

Average Dose.—Metric, 15 mils.; apothecaries, 4 fluidrachms.

## PETROLATUM, U. S. P.
**Petrolat.—Petrolatum Ointment, Petroleum Jelly.**

A purified mixture of semi-solid hydrocarbons obtained from petroleum.

Petrolatum is an unctuous mass, varying in color from yellowish to light amber, having not more than a slight fluorescence even after being melted. It is transparent in thin layers, completely amorphous, free or nearly free from odor or taste.

Petrolatum is insoluble in water, almost insoluble in cold or hot alcohol or in cold dehydrated alcohol, freely soluble in ether, chloroform, carbon bisulphide, oil of turpentine, petroleum benzin, benzene or in most fixed or volatile oils.

Specific gravity, 0.820 to 0.865 at 60°C.

It melts between 38° and 54°C.

Heat about 2 gms. of Petrolatum in an open porcelain or platinum dish over a Bunsen burner flame. It volatilizes without emitting an acrid odor and on incineration not more than 0.05% of ash remains.

Shake melted Petrolatum with an equal volume of hot distilled water; the latter remains neutral to litmus (acid or alkalies).

Digest 10 grams of Petrolatum at 100°C for half an hour with 10 gms. of sodium hydroxide and 50 mils. of distilled water, then separate the aqueous layer and supersaturate it with sulphuric acid; no oils or solid substance separates (fixed oils, fats or rosin).

## PETROLATUM ALBUM. U. S. P.
**White Petrolatum.**

**Petrolat. Alb.—White Petroleum Jelly.**

Petrolatum wholly or nearly decolorized.

White Petrolatum is a white or faintly yellowish unctuous mass, transparent in thin layers even after cooling to 0°C, completely amorphous.

In other respects White Petrolatum has the characteristics of and responds to the tests for identity and purity under Petrolatum.

## PARAFFINUM, U. S. P.
### Paraffin.

A purified mixture of solid hydrocarbons usually obtained from petroleum.

Paraffin is a colorless or white more or less translucent mass, crystalline when separating from solution, without odor or taste and slightly greasy to the touch.

It is insoluble in water or alcohol, slightly soluble in dehydrated alcohol, freely soluble in ether, petroleum benzine, benzene, carbon disulphide, volatile oils or in most warm fixed oils.

Specific gravity, about 0.900 at 25°C.

It melts between 50° and 57°C.

When strongly heated it ignites, burns with a luminous flame and deposits carbon.

Heat about 0.5 gm. of paraffin in a dry test tube with an equal weight of sulphur; the mixture becomes black from separated carbon and hydrogen sulphide gas is evolved.

Paraffin is not acted upon or colored by concentrated sulphuric or nitric acid in the cold.

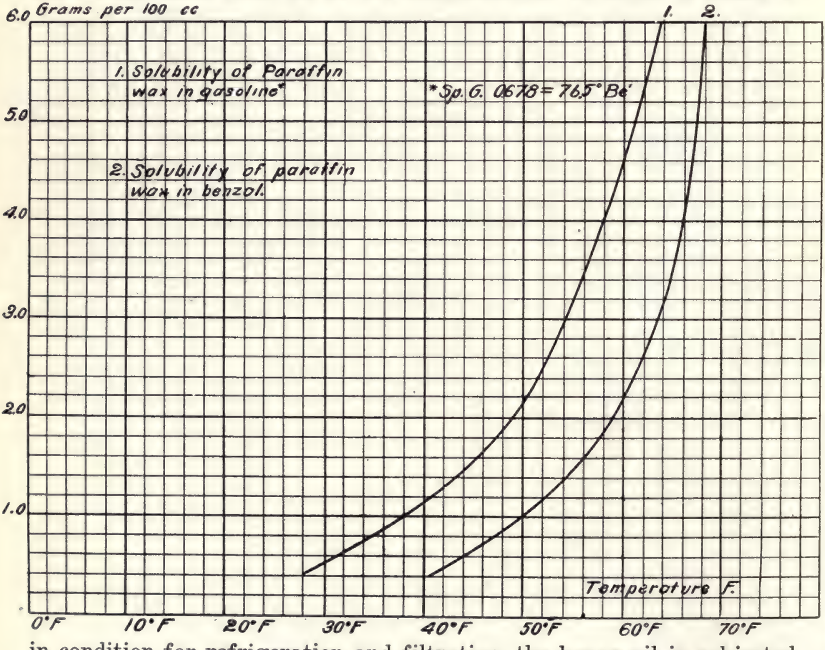
Shake melted paraffin with an equal volume of hot alcohol; the separated alcohol does not redden moistened blue litmus paper (acids).

**Ichthyol** is an artificial preparation obtained by the distillation of certain bituminous shales and subsequent sulphonation and neutralization with ammonia or soda. It comes on the market under the official name of Ammonii Icythyo-sulphonas or Ammonium Sulpho-ichthyolate. The specific gravity of the preparation is approximately 1.0, and it has a viscosity of 17.7 (Engler). A typical preparation contains 15% to 16% of sulphur, and it is to the sulphur that the value of the preparation is largely due. On account of the difficulty in duplicating exactly the original product and the scarcity of the original product, it has now attained a very high price.

# Paraffin Wax

Paraffin wax is valued by the color, melting point and the specific gravity. The price of the crude wax having a melting point of from 103°F to 108°F is about 6c per pound, while the highly refined wax having a melting point of up to 140°F is worth about 17c per pound.

Paraffin wax is ordinarily obtained from petroleum; also from shale oil and ozocerite. Paraffin exists in crude petroleum in the form of protoparaffin, in which condition it does not crystallize out and cannot be expressed from oil at low temperatures. In order to obtain it




in condition for refrigeration and filtration, the heavy oil is subjected to a destructive distillation, thereby producing the crystalline pyroparaffin.

Pennsylvania petroleum furnishes from 1½% to 2% paraffin wax, some petroleum such as one in Roumania giving as much as 10%.

The wax distillate from which paraffin is obtained contains ordinarily about 10% of wax. This distillate has a gravity of from 33°Be' to 35°Be' and distills over at a temperature of 500°F to 700°F. The paraffin is freed from oil by the sweating process after filtration.

# Fuel Oil

Petroleum as a fuel for use in steam plants has considerable variation, the only feature common to all oils coming under this class being that it is free from gasoline.

The gravity varies according to the character of the oil and the amount of light constituents that have been distilled out of it. The following table shows typical gravities of fuel oil from different sources.

| | Gravity |
|---|---|
| Mexican fuel oil | 12.6°Be′ |
| Paraffin base fuel oil | 27.5°Be′ |
| California fuel oil | 15.5°Be′ |
| Towanda fuel oil | 26.0°Be′ |
| Mid-Continent heavy fuel oil | 23.5°Be′ |
| Typical Mid-Continent oil | 26.5°Be′ |
| Garber, Oklahoma, fuel oil | 31.3°Be′ |

The chief property making fuel oil available for use is the ease with which it flows, or its viscosity. The viscosity is not proportional to the gravity, as is indicated by the following table:

**Viscosity and Gravity of Fuel Oils (See Pages 187-8).**

| Source | Gravity | Viscosity at 70°F |
|---|---|---|
| California crude | 16.9°Be′ | 5400 |
| Residuum from same after cracking | 15.5 | 414 |
| Heavy Kansas crude | 19.7 | 3360 |
| Residuum from same after cracking | 21.2 | 178 |
| Heavy Mid-Continent fuel oil | 23.5 | 810 |
| Residuum from same after cracking | 21.2 | 135 |
| Garber, Oklahoma, fuel oil | 31.3 | 183 |
| Residuum from same after cracking | 28.0 | 70 |
| Mexican heavy flux oil | 10.8 | 14500 |
| Residuum from same after cracking | 12.6 | 530 |
| Average Mid-Continent fuel oil | 27.5 | 272 |
| Residuum from same after cracking | 23.7 | 88 |

Fuel oil has a remarkably constant heating value based on British thermal units per pound of oil. Oil free from water has a higher B.T.U. per pound and a lower B.T.U. per gallon, the lighter the oil; and a lower B.T.U. per pound and a higher B. T. U. per gallon, the heavier the oil. This is set forth in the curves on page 189.

As compared with other sources of heat the theoretical amount of heat obtainable from petroleum or fuel oil as determined when the combustion is complete and the absorption of heat is complete is as follows:

| | |
|---|---|
| 1,000,000 B. T. U. of Petroleum @ $1.00 per bbl. costs | $0.165 |
| 1,000,000 B. T. U. of Cherokee slack coal @ $3.00 per ton | 0.136 |
| 1,000,000 B. T. U. of natural gas @ $0.30 per 1,000 cu. ft. = | 0.33 |
| 1,000,000 B. T. U. of coal gas @ $0.50 per 1,000 cu. ft. = | 0.79 |
| 1,000,000 B. T. U. of electricity @ 1c per k.w.hour = | 2.93 |

The above data is from the following: Fuel oil based on specific gravity 0.900 = 25.7°Be′, weight per gallon, 7.5 lbs., weight per barrel 315 lbs.

B. T. U. per lb. = 19,225, per ton = 38,450,000, per gallon = 144,200, cubic foot = 1,078,500, per barrel = 6,056,000.

Slack coal = 11,000 B. T. U. per pound.

Natural gas = 900 B. T. U. per cubic foot.

**Equivalents.**

1 ton of coal = 3.6 bbls. oil = 24,500 cu. ft. of natural gas.
1 gallon of oil = 13.1 lbs. coal = 160 cu. ft. of natural gas.
1 barrel oil = 0.278 ton coal = 680.6 cu. ft. of natural gas.
1 pound oil = 1.75 lbs. coal = 21.3 cu. ft. of natural gas.
1 pound coal = 0.763 gallon oil = 12.2 cu. ft. of natural gas.

As to the actual heating value of fuel oils from various sources the following is representative:

**Heating Value of Fuel Oils.**

| | Mid Continent Av'ge 1255 Samples | Light Mid Continent | Heavy Mid Continent | To'da Fuel Oil | Gas Oil | Mexican |
|---|---|---|---|---|---|---|
| Specific gravity..... | 0.892 | .863 | 0.922 | 0.921 | 0.856 | 0.975 |
| Baume' gravity...... | 26.9 | 32.2 | 21.8 | 22.0 | 33.5 | 12.6 |
| Weight per gal. (lbs) | 7.43 | 7.18 | 7.68 | 7.67 | 7.13 | 8.25 |
| Heat value B. T. U. per pound......... | 19376 | 19580 | 19170 | 19175 | 19635 | 18710 |
| Heat value B. T. U. per gallon....... | 143950 | 140580 | 157220 | 147600 | 139990 | 154360 |
| Flash point........ | 125°F | 110°F | 132°F | 180°F | 170°F | 100°F |
| Sediment ........... | 1.0 % | 0.2 % | 1.5 % | 1.0 % | 0.0 % | 2.0 % |
| Sulphur ........... | 0.3 % | 0.24% | 0.65% | 0.75% | 0.05% | 2.5 % |

It is to be noted that purchasers obtain more heat from a heavy fuel oil as it is purchased on the basis of the gallon.

The chief impurities found in fuel oil are water or brine and asphaltic sediment. The asphaltic sediment has almost as great heating value as the oil itself but the brine or water very greatly diminish the heatin value as well as interfere with the mechanical use of the oil.

The price of coal is the most important factor governing the price of fuel oil. In a general way it is claimed that one unit of heat from oil will produce the same amount of steam as 1.4 units of heat from coal. This takes into consideration the higher efficiency in using the oil, the greater ease in handling, the absence of certain mechanical features attendant upon the use of coal but does not consider the flexibility of the oil where this is a necessary feature of the power plant. According to this one pound of oil would be equivalent to 2½ pounds of coal or one barrel of oil would be equivalent to .45 ton of coal. Oil at $2.00 per barrel would be equivalent to slack coal at $4.45 per ton. This assumes that the slack has a heating value of about 10,000 B. T. U. per pound.

**Specifications for Fuel Oil of U. S. Navy.**

The specifications for navy fuel oil, gas oil and bunker oil, Atlantic and Gulf ports, are:

**1. Methods of Test.**

(a) Flash point will be taken as indicated in the specifications.
(b) Viscosity will be taken by the Engler viscosimeter (see note under "2. Specifications")

(c) Water and sediment will be taken by the distillation method. When oil in small lots is consigned to naval vessels or to navy yards the centrifugal test will be used in order to obviate delay. In this test 30 cc. of oil and an equal quantity of best commercial benzol, 50% white will be used and the mixture heated to 100°F.

**2. Specifications.**

(a) Fuel oil shall be a hydrocarbon oil free from grit, acid and fibrous or other foreign matter likely to clog or injure the burners or valves. If required by the Navy Department it shall be strained by being drawn through filters of wire gauge having 16 meshes to the inch. The clearance through the strainer shall be at least twice the area of the suction pipe and strainers shall be in duplicate.

(b) The unit of quantity to be the barrel of 42 gallons of 231 cu. in. at a standard temperature of 60°F. For every decrease or increase of temperature of 10°F (or proportion thereof) from the standard 0.4 of 1% (or prorated percentage) shall be added or deducted from the measured or gauged quantity for correction.

(c) The flash point shall not be lower than 150°F as a minimum (Abel or Pennsky-Marten's closed cup) or 175°F Tagliabue open cup. In case of oils having a viscosity greater than 8 Engler at 150°F the flash point (closed cup) shall not be below the temperature at which the oil has a viscosity of E Engler.

(d) Viscosity shall not be greater than 40 Engler at 70°F.

(e) Water and sediment not over 1%. If in excess of 1% the excess to be subtracted from the volume or the oil may be rejected.

(f) Sulphur not over 1/5%.

Note:—If the Engler viscosimeter is not available, the Saybolt standard universal viscosimeter may be used. Equivalent viscosities:

88 Engler.................... 300 seconds Saybolt
40 Engler....................1,500 seconds Saybolt

## FUEL OIL FOR DIESEL ENGINES.

Explosion Engine oils should have the following properties:

1. Specific gravity shall be below 0.920.
2. Water shall be below 1%.
3. Flash point shall be between 60°C—100°C.
4. Volatility shall be 80% or more at 350°C in Engler flask.
5. Cold test shall be below 32°F.
6. Coke shall be less than 3%.
7. Sulphur shall be below 0.75%.
8. Solubility in xylene shall be more than 99.5%.
9. Acids and alkalies shall be absent.

Some of the advantages claimed for liquid fuel under boilers are: (Poole—Calorific Power of Fuels.)

1. Diminished loss of heat up the stack owing to the clean condition in which the tubes can be kept, and to the smaller amount of air which has to pass through the combustion-chamber for a given fuel consumption.

2. A more equal distribution of heat in the combustion-chamber as the doors do not have to be opened and consequently a higher efficiency is obtained.

3. With oil there is no chance of getting dirty fires on a hard run as with coal.

4. A reduction in cost of handling fuel, since oil is handled

mechanically or by gravitation while with solid fuel, manual labor is required.

5. No firing tools or grate bars are used, consequently the furnace lining and brickwork floors, etc., suffer less damage.

6. No dust nor ashes to cover or fill the tubes and diminish the heating surface, nor to be handled or carted away.

7. Petroleum does not suffer while being stored, while the deterioration of coal under atmospheric influence is well known.

8. Ease with which fire can be regulated from a low to a most intense heat in a short time.

9. Absence of sulphur or other impurities and longer life of plates, etc.

10. Lessening of manual labor of fireman.

11. Great increase of steaming capacity.

For burning liquid fuel the best burner is that which atomizes or sprays the fuel. By thus forming a fine mist an approximation to the theoretical fuel, gas, is obtained. Several methods are in use for this purpose. By some the oils are vaporized by heat but this is applicable only to light oils which are not much used. The favorite method is by having the burner so constructed that the oil is forced out in a spray and at the same time mixed with the air necessary for its combustion.

To have the best results, the burner must be so regulated as to have a flame bordering on, but not quite, smoky. Thus sufficient and not too much air is obtained. The quantity of steam needed to atomize the oil is about 4% of the water evaporated.

## MISCELLANEOUS FACTS CONCERNING HEATING BY OIL.

Good practice in the atomization of fuel oil requires an average of 0.3 pound of steam per pound of oil burned.

One pound of fuel oil requires 14 to 15 pounds or 200 cubic feet of air for complete combustion. 225 cubic feet is good practice.

The stack gases from an oil furnace for the highest efficiency should not contain less than 15% of carbon dioxide (over 13% is good).

The temperature of an oil flame with complete combustion and without an excess of air is about 3750°F. (Natural gas flame, 3250°F.)

One pound of oil will yield on combustion 16 to 17 pounds of gases of combustion or 400-500 cubic feet at a temperature of 400°F.

Oil is successfully used in melting iron and steel scrap. For this purpose it is much superior to coal on account of the absence of mineral matter and the very much smaller amount of sulphur.

One barrel of oil will melt one ton of steel in the reverberatory furnace, with the furnace walls already hot.

A typical malleable iron foundry by the changing of the furnaces from coal to oil fuel increased the strength of their castings 100% and increased the output 20%.

Diesel engines consume from .45 to .7 pound of heavy oil per brake H. P. per hour.

Oil requires 60% of stack area needed for coal firing.

Oil gives a fuel efficiency at least 10% greater than coal.

The advantages of oil fuel installations for locomotives and boats have been found to be as follows:

(a) Economy of space reserved for carrying fuel; 50% more fuel value per unit space.

(b) Ease in filling tanks.

(c) Rapidity of time in meeting a varying load on boiler. Fires may be instantly lighted.

(d) Ability to force boiler to extreme duty in case of emergency.

(e) Short height of stack.

(g) Superior personnel available for the operation of the burners.

(h) Ability to secure and maintain higher speed with oil fuel than with coal. No deterioration in storage.

In the distillation of crude oil in which 50% of the crude is distilled off as benzine and kerosene, in good practice, 2.8 barrels of fuel oil are used per 100 barrels of crude oil treated.

For all refining purposes in the production of gasoline, naphtha and kerosene only, from 6 to 7 barrels of fuel oil are required for each 100 barrels of crude treated, assuming that 50% of the lighter hydrocarbons are distilled from the crude.

One-fourth of a gallon of fuel oil is required to produce one gallon of 58° Baume' gasoline by cracking according to a pressure distillation process now extensively used.

The **specific heat** of petroleum is about 0.5 (.49-.53), the **heat of vaporization** averages about 130 B. T. U. per pound and the **heat of fusion** 63 B. T. U. per pound (Paraffin).

For Natural Dry Petroleum of Paraffin or Semi-Paraffin Base the following relation of gravity (Baume-U. S.) and heating value holds:

$$\text{B. T. U. per pound} = 18700 + 40\ (\text{Be}'\text{-}10).$$

## SAMPLING OF FUEL OIL.

The accuracy of tests depends upon the care with which an average representative sample of the fuel oil delivery has been taken and the importance of obtaining such a sample cannot be overestimated. Top, middle and bottom samples should be taken with a standard "car thief" and these samples should be combined and thoroughly mixed to form one sample for car deliveries. Where oil is received in tanks or reservoirs the swing pipe should first be locked at a position well above the level of the water and sediment usually found in the bottom of such tanks. Tanks schould be sampled every foot for the first five feet above the bottom of the swing pipe, and at five-foot intervals from there to the surface of the oil. This sampling should be done with a standard tank thief, the samples "cut" individually, and deductions for impurities made on the separate volumes which these samples represent. If the tank is a large one, it should be sampled through at least two hatches. In receiving large deliveries of the more viscous oils it is necessary to take many samples in order to insure fair and average impurity (M. & B. S.) deductions. This is because water and sediment do not readily settle out of such oils.

# Natural Gas Fuel and Producer Gas Costs

The following table of Producer Gas Costs includes fuel, power, repairs and maintenance, labor and supervision, interest and depreciation, in fact, every item of cost except the interest and taxes on the land occupied.

| Producer Gas Costs per 1000 Cu. Ft. for Coal Costs Given | | | Costs at Which Other Fuels Must be Bought to Obtain the Same Number of B. T. U. as When Buying Producer Gas With Coal at the Price Given | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Natural Gas per 1000 Cu. Ft. | | Fuel Oil per Gallon | | Coal Gas or Carburetted Water Gas per 1000 Cu. Ft. | | Blue Gas per 1000 Cu. Ft. | |
| Cost of One Ton of Coal | Hot Raw Producer Gas at Offtake | Clean Cold Producer Gas | Hot Raw Gas | Clean Cold Gas | Hot Raw Gas | Clean Cold Gas | Hot Raw Gas | Clean Cold Gas | Hot Raw Gas | Clean Cold Gas |
| $2.00 | 3.13c | 4.15c | 23.7c | 31.5c | 2.91c | 3.86c | 12.6c | 16.72c | 6.45c | 8.59c |
| 2.50 | 3.55 | 4.57 | 26.9 | 34.67 | 3.3 | 4.25 | 14.3 | 18.40 | 7.34 | 9.45 |
| 3.00 | 3.96 | 4.98 | 30.1 | 37.84 | 3.69 | 4.64 | 16.6 | 20.09 | 8.20 | 10.32 |
| 3.50 | 4.38 | 5.40 | 33.3 | 41.01 | 4.08 | 5.03 | 17.65 | 21.77 | 9.07 | 11.18 |
| 4.00 | 4.79 | 5.82 | 36.3 | 44.18 | 4.46 | 5.42 | 19.3 | 23.45 | 9.92 | 12.05 |
| 4.50 | 5.21 | 6.24 | 39.5 | 47.35 | 4.85 | 5.81 | 21. | 25.13 | 10.78 | 12.91 |
| 5.00 | 5.63 | 6.66 | 42.7 | 50.52 | 5.24 | 6.20 | 22.7 | 26.82 | 11.65 | 13.78 |
| 5.50 | 6.05 | 7.08 | 45.9 | 53.69 | 5.63 | 6.59 | 24.35 | 28.50 | 12.5 | 14.64 |
| 6.00 | 6.46 | 7.49 | 49.1 | 56.85 | 6.01 | 6.97 | 26.0 | 30.18 | 13.36 | 15.50 |

HEATING VALUES USED

| | |
|---|---|
| Producer Gas | 145 B. T. U. per cu. ft. |
| Natural Gas | 1,100 B. T. U. per cu. ft. |
| Fuel Oil | 135,000 B. T. U. per gallon |
| Coal Gas or Carburetted Water Gas | 585 B. T. U. per cu. ft. |
| Blue Gas | 300 B. T. U. per cu. ft. |

Note: These costs are based on the plant operating with a 100% load factor, that is, operating at rated capacity 24 hours per day, 365 days per year. Comparatively few plants have a 100% load factor, therefore, it is necessary to take this very important point into consideration when estimating the cost of gas.

The cost of Producer Gas, with a reasonable degree of accuracy may be estimated for any load factor by applying the formula:

$$C = T + \left\{ \left( \frac{R \times 400}{A \times B} \right) - 2.38 \right\}$$

Where C = Cost of Producer Gas per 1000 cu. ft. under conditions specified.

A = Number of feet of gas used per day.

B = Days per week plant is in operation.

T = Cost figures shown in table at 100% load factor.

R = Rated hourly capacity of plant in cubic feet.

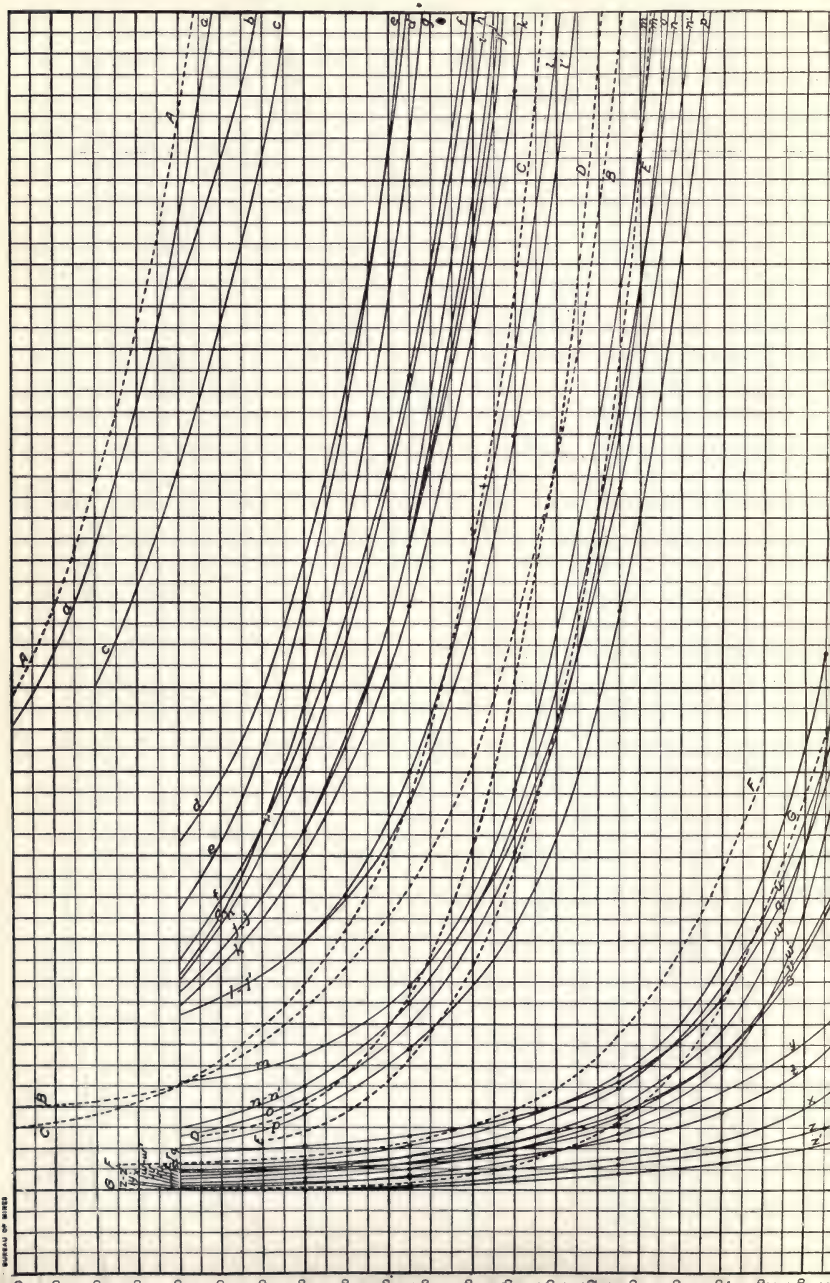
It also must be kept in mind that furnace efficiencies have a very great bearing on the cost of the finished product. Without regeneration or recuperation Producer Gas cannot be used as efficiently as the more concentrated fuels.

The expense of the distribution system and the furnaces also have an important bearing on the total cost of doing the work.

## KEY TO PAGE 188.

| Curve No. | TYPE OF OIL | Gravity | | Flash point, °F |
|---|---|---|---|---|
| | | Specific | °Be′ | |
| | Solid curves | | | |
| a | Mexican residue. | 1.000 | 10.0 | 374 |
| b | "Toltec fuel oil," Inter-Ocean Oil Co., N. Y. | .988 | 11.7 | 220 |
| c | "Toltec or Panuco oil," Inter-Ocean Oil Co. | .986 | 12.0 | 124 |
| d | "No. 102," Union Oil Co., Bakersfield, Cal. | .980 | 12.9 | 280 |
| e | "No. 18," Union Oil Co., Bakersfield, Cal. | .980 | 12.9 | 285 |
| f | "Standard" Mexican crude (lot 2) | .964 | 13.4 | 202 |
| g | "No. 25," Union Oil Co., Bakersfield, Cal. | .978 | 13.2 | 262 |
| h | Mexican crude, Texas Co. | .952 | 17.3 | 126 |
| i | Sample No. 3, Anglo-Mex. Pet. Products Co. | .952 | 17.3 | 164 |
| j | "Gaviota Refinery," Associated Oil Co., Cal. | .953 | 17.1 | 230 |
| j′ | Mexican oil, Atlantic torpedo flotilla, March, 1914. | .947 | 18.1 | 182 |
| k | Standard Mexican crude (lot 1) | .954 | 17 0 | 145 |
| l | Mexican oil, U. S. S. Arethusa | .950 | 17.6 | 182 |
| l′ | "Nos. 1, 2, 3," Anglo-Mexican Pet. Products Co. | .955 | 16.8 | 188 |
| m | Producers Crude No. 1 fuel oil, Union Oil Co., California. | .959 | 16.1 | 174 |
| n | "Coalinga Field," Associated Oil Co., Monterey, Cal. | .957 | 16.5 | 186 |
| n′ | "Avon Refinery," Asso'd Oil Co., Avon, Cal. | .953 | 17.1 | 168 |
| o | Richmond, California. | .953 | 17.1 | 228 |
| p | Sun Co., Louisiana | .936 | 19.8 | 275 |
| q | "Standard," Illinois. | .893 | 27.3 | 146 |
| r | Gulf Refining Co., Navy standard oil, U. S. S. Perkins. | .892 | 27.5 | 180 |
| s | "Standard," Indiana. | .880 | 29.6 | 144 |
| t | "Standard Star," California | .912 | 23.9 | 180 |
| u | "Standard," Illinois (lot 4) | .893 | 27.3 | 146 |
| v | "Standard," Indiana (lot 4) | .880 | 29.6 | 144 |
| w | Gulf Refining Co., Navy contract | .882 | 29.3 | 170 |
| w′ | "Standard," Lima, Ohio, crude | .876 | 30.4 | 149 |
| x | Camden Chemical Co., by-product of coal tar. | | | |
| y | "Star," California. | .912 | 23.9 | 180 |
| z | Gulf Refining Co., Navy standard oil, U. S. S. Roe. | .885 | 28.7 | 182 |
| z′ | Standard Mexican gas oil | .856 | 34.2 | 151 |
| ● | Indicates test results. | | | |
| | Dotted curves | | | |
| A | Panuca crude, Inter-Ocean Oil Co | .975 | 13.7 | 140 |
| B | Mexican petroleum, Texas Co | .938 | 19.5 | 234 |
| C | Associated Oil Co., California | .971 | 14.2 | 257 |
| D | Bakersfield, Cal., pipe line to Port Costa | .970 | 14.4 | 260 |
| E | California Standard Oil Co., steamer Santa Barbara. | .962 | 15.7 | 282 |
| F | Beaumont, Tex., Gulf Refining Co | .907 | 24.8 | 222 |
| G | Navy standard oil, Texas Co | .911 to .900 | 24 to 26 | 195 to 220 |

From "Oil Fuel Handbook."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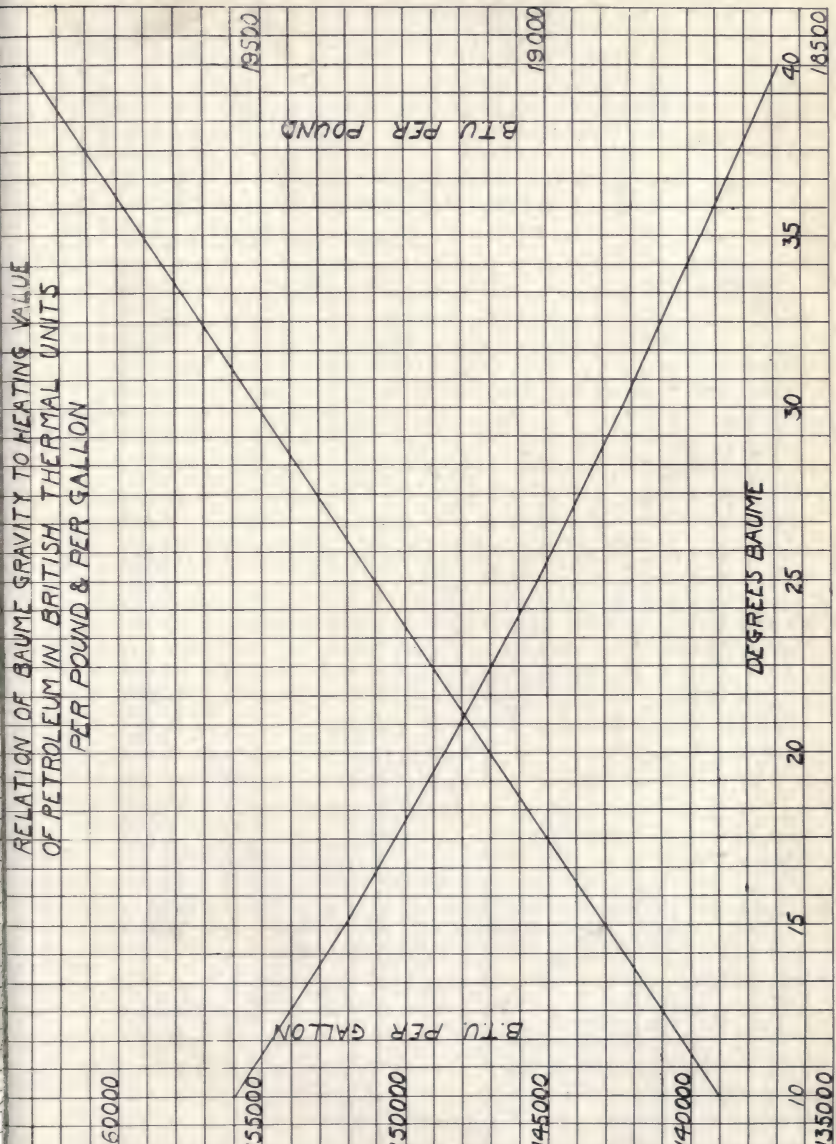

RELATION OF BAUME GRAVITY TO HEATING VALUE
OF PETROLEUM IN BRITISH THERMAL UNITS
PER POUND & PER GALLON
B.T.U. PER POUND
19500
19000
18500
DEGREES BAUME
10
15
20
25
30
35
40
B.T.U. PER GALLON
160000
155000
150000
145000
140000
135000

# Heating Value of Various Substances

| | Calories per gram. | B. T. U. per lb. of Combustible Matter. |
|---|---|---|
| Alcohol, grain | 7,054 | 12,697 |
| Alcohol, wood | 5,330 | 9,594 |
| Asphalt, 60° pen. | 9,532 | 17,159 |
| Benzol | 10,030 | 18,054 |
| Carbon or Coke | 8,137 | 14,647 |
| Gas, Acetylene | 11,527 | 20,749 |
| Gas, Coal, Min. | 4,440 | 7,990 |
| Max. | 7,370 | 12,266 |
| Gas, Methane | 13,344 | 24,019 |
| Gas, Water | 2,350 | 4,230 |
| Gas, Hydrogen | 34,462 | 62,032 |
| Iron | 1,582 | 2,848 |
| Coal, Pa. Anthracite | 8,266 | 14,880 |
| Coal, West Va. Bituminous | 8,778 | 15,800 |
| Coal, Wyoming Lignite | 7,444 | 13,400 |
| Coal, North Dakota Lignite | 6,411 | 11,540 |
| Coal, Kansas Bituminous | 8,461 | 15,230 |
| Coal, Illinois Bituminous | 8,056 | 14,500 |
| Coal, Cannel (Missouri) | 8,980 | 16,165 |
| Coal, Peat | 5,940 | 10,692 |
| Cottonseed Oil | 9,500 | 17,100 |
| Gasoline, avg. | 11,528 | 20,750 |
| Fuel Oil, avg. | 10,833 | 19,500 |
| Shale Oil | 10,970 | 19,750 |
| Paraffin wax | 11,140 | 20,050 |
| Sulphur | 2,241 | 4,034 |
| Wood | 4,750 | 8,550 |
| Naphthalene | 9,690 | 17,442 |
| Gilsonite | 9,944 | 17,900 |
| Hard Asphalt from petroleum | 9,989 | 17,980 |
| Blown Asphalt from petroleum | 10,210 | 18,380 |

# Refining of Oil for Road Building and Paving Purposes

The various methods of refining which yield residues adaptable or used for road building and paving purposes are as follows:

Sedimentation.
Dehydration.
Fractional distillation by direct fire.
Forced fire distillation with direct fire.
Steam distillation.
Inert gas distillation.
Air blowing.

In the types of oil which are ordinarily used for making asphalt or road binders, water is one of the most common impurities. The water is ordinarily salt water and may contain more or less other mineral matter than the salt. These impurities are insoluble in the bitumen proper, and, as they differ from the bitumen in specific gravity, they may be removed wholly or in part by the process of sedimentation or separation by gravity. In the more fluid petroleums sedimentation occurs during storage in the large tanks and the water is ordinarily automatically drawn off from the bottom of the tank by reason of the different pressure produced by the salt water and by the oil. However, a small amount of emulsified water nearly always remains in all petroleums, so that there will always be a small amount of sediment. If the petroleum is very heavy and viscous, approximately equal in gravity to water, then the water will remain emulsified and will not separate by gravity. This type of oil happens to be the most suitable in quality for producing asphalt, and special means of removing this water is necessary before the oil can be reduced to the desired consistency. The dehydration processes are designed primarily for removal of the water in the bituminous material which will not completely separate by sedimentation. It is desirable to do this before distillation because of the fact that the presence of the water will cause foaming when the mixture is heated to the temperature of boiling water. Dehydrating plants vary considerably in design, but those more commonly used for petroleum in California are spoken of as topping plants. In this sort of plant the oil is pumped with or without pressure through a length of pipe containing many bends and turns, so that the oil is considerably stirred. The pipe coils are set in furnaces, so that they may be suitably heated to a temperature above that of boiling water. This pipe discharges the foam into a large expansion chamber, where the water and more volatile constituents separate in the form of vapor, which is condensed in an ordinary condenser for the recovery of the light products. This sort of plant is commonly spoken of as a pipe still. From the pipe still the oil passes through another line, direct to a large batch still, where it is subjected to the ordinary fractional distillation.

The essential principle in the distillation of an oil for road purposes is that it shall distill at a temperature sufficiently low to prevent the decomposition of the hydrocarbons. Since asphalt hydrocarbons begin to decompose at a temperature of 600°F or slightly below, it is desirable that the fire distillation be carried only to that temperature. After this temperature has been reached, the usual method is to blow superheated steam, which mechanically carries over

the more volatile hydrocarbons at a temperature much below tʰ actual boiling point.

This distillation has a special action in removing the paraffı compounds which are particularly undesirable in that they have very little ductility and cementition value. The distillate will contain any light oils such as are used as spindle oils and for general lubrication, as well as any paraffin wax. It is particularly desirable in this distillation to prevent the formation of free carbon or coke. The distillation with steam may be carried down until the residue shows a penetration of about 10 millimeters.

A method of distillation which gives very great yields of solid or semisolid asphalt even from semiparaffin base oils is that of blowing the oil at moderately high temperature with air. This in many Mid-Continent oils gives much more asphalt than naturally exists in the oil. The action of the air is to produce a more viscous product which is very much less susceptible to temperature changes than the natural asphalt. It is strictly a chemical transformation process formed from the hydrocarbons in the oil which are ordinarily not useful for asphalt making purposes. It has been found from practical experience that this type of asphalt is not sufficiently cementitious and ductile to be used for ordinary paving purposes in producing first-class asphalt pavement. It can, however, be successfully used and is in great demand for waterproofing purposes, for filler in brick and wood block pavement and for roofing purposes and for fluxing ductile asphalt.

The best types of petroleum for asphalt paving purposes are thos from California, Mexico, Trinidad and Texas.

Asphalt production in 1917 from domestic petroleum was 701,8 short tons valued at $7,734,690. This includes 327,142 tons of ser solid and 374,677 tons of semi-fluid asphalt. The total manufactı asphalt from Mexican petroleum was 645,613 tons. The import native asphalt and asphalt rock in 1917 was 187,886 tons.

## ASPHALT PAVEMENT

Asphalt is a black non-oxidized bituminous hydrocarbon, sen fluid to hard in consistency, the heavy residuum from petroleum or occurring naturally. The residua from petroleum are known as o asphalts and come most largely from California, Mexican, Texas anu Mid-Continent petroleums. The most commonly used natural asphalts are Trinidad, Bermudez, Cuban and Gilsonite.

The term asphalt is commonly applied to bituminous pavements, being mixtures usually of oil asphalt with dust, sand, gravel or rock in varying proportions from 6% to 20%. The terms "bitumen" or "asphaltic cement" are commonly applied to the pure asphalt material.

The types of asphalt construction now commonly used are:

1. Asphaltic concrete. This mixture is very common in localities where Joplin chats are available. It is known also as "Topeka Specification Pavement" and "Bituminous Concrete," but it might be called bituminous gravel. The stone it carries is of ½″ and ¼″ size.

2. Sheet asphalt is the original type of asphalt pavement laid in two courses, the bottom one with coarse stone, the top with sand mixed with the bitumen.

3. Bituminous concrete (Warren) is laid with coarse stone in the wearing surface.

4. Bituminous earth is laid without an appreciable amount of sand or rock.

There are two different basic principles involved in proportioning mineral matter of an asphalt pavement. One is to so grade the rse mineral particles that they support each other and interlock. he other is to produce a mastic of bitumen and finely divided earthy naterial that is rigid and self-supporting because of surface tension action. This mastic fills the voids in the coarse material and has a much higher melting point than the pure bitumen and does not so eadily allow softening or movement of the pavement.

### COMPOSITION OF NATURAL ASPHALT

| | Natural Trinidad | Bermudez | Gilsonite | Grahamite | Cuban |
|---|---|---|---|---|---|
| Bitumen | 56.0% | 94.0% | 99.4% | 94.1% | 75.1% |
| Mineral Matter | 36.8% | 2.0% | 0.5% | 5.7% | 21.4% |
| Specific Gravity | 1.400 | 1.085 | 1.045 | 1.171 | 1.305 |
| Fixed Carbon | 11.0% | 13.5% | 13.0% | 53.3% | 25.0% |
| Melting Point, °F | 190 | 180 | 300 | Cokes | 240 |
| Penetration | 0.5 | 2.5 | 0 | 0 | 0 |
| Free Carbon | 6.0% | 4.0% | 0.1% | 0.2% | 3.5% |
| Sulphur (ash free basis) | 6.5% | 5.6% | 1.3% | 2.0% | 8.3% |
| Petroleum ether soluble | 65.0% | 70.0% | 30.0% | 0.4% | 41.1% |
| Total Carbon (ash free) | 82.6% | 82.5% | | 87.2% | |
| Hydrogen (ash free) | 10.5% | 10.3% | | 7.5% | |
| Nitrogen (ash free) | 0.5% | 0.7% | | 0.2% | |

### COMPOSITION OF OIL ASPHALTS

| | Mexican | Mid-Continent Air Blown | California | Stanolind (cracked-pressure tar residue) |
|---|---|---|---|---|
| men. | 99.5% | 99.2% | 99.5% | 99.8% |
| eral Matter | 0.3% | 0.7% | 0.3% | 0.3% |
| cific Gravity | 1.040 | 0.990 | 1.045 | 1.060 |
| ed carbon | 17.5% | 12.0% | 15.0% | 17.5 |
| lting Point °F | 140 | 180 | 140 | 135 |
| netration | 55 | 40 | 60 | 50 |
| Free Carbon | 0.0 | 0.0 | 0.0 | 0.0 |
| lphur (ash free basis) | 4.50% | 0.60% | 1.65% | 0.35 |
| Petroleum Ether Soluble | 70.0% | 72.0% | 67.0% | 70.0% |
| Cementing Properties | good | poor | good | good |
| Ductility | 45 cm | 2 cm | 70 cm | 100+ |
| Loss at 32°F. 5 hrs | 0.2% | 0.1% | 0.2% | 0.1% |
| Heat test | adherent | smooth | adherent | scaly |

# Composition of Rock Asphalt

## ASPHALTIC LIMESTONES

| | Ragusa Sicily | Seyssel France | Mons France | Cass Co. Missouri | Buckhorn Oklahoma |
|---|---|---|---|---|---|
| Bitumen | 9.9% | 5.9% | 8.9% | 6.9% | 5.9% |
| Passing 200 mesh | 37.1 | 44.1 | 53.1 | 20.0 | 9.0 |
| 80 " | 23.0 | 15.0 | 13.0 | 21.0 | 8.4 |
| 50 " | 14.0 | 9.0 | 7.0 | 17.0 | 9.0 |
| 40 " | 4.0 | 7.0 | 5.0 | 6.0 | 9.9 |
| 30 " | 2.0 | 7.0 | 3.0 | 6.5 | 15.0 |
| 20 " | 5.0 | 6.0 | 5.0 | 5.1 | 8.8 |
| 10 " | 5.0 | 6.0 | 5.0 | 7.5 | 8.0 |
| 4 " | 0.0 | 0.0 | 0.0 | 10.0 | 26.0 |
| Calcium carbonate | 89.0 | 91.3 | 90.0 | 92.9 | 96.0 |

## ASPHALTIC SANDSTONES

| | Breckenridge County, Ky. | Buckhorn District Oklahoma | Higginsville, Missouri |
|---|---|---|---|
| Bitumen | 9.2% | 9.2% | 7.9% |
| Passing 200 mesh | 5.2 | 1.5 | 25.7 |
| 80 " | 45.5 | 56.5 | 71.3 |
| 40 " | 36.3 | 30.4 | 3.0 |
| 10 " | 3.8 | 2.4 | 0.0 |
| Calcium carbonate | 0.0 | 0.0 | 0.0 |

# Composition of Asphalt Pavements

The following table gives a comparison of a typical composition and properties of good mixtures representing the various types of asphalt wearing surface pavements:

| | Bituminous Concrete (Topeka Spec.) | Bituminous Concrete (Warren) | Sheet Asphalt | Bituminous Earth "National" |
|---|---|---|---|---|
| Asphaltic cement | 8.0% | 6.0% | 10.0% | 20.0% |
| Dust passing 200 mesh screen | 12.0 | 5.5 | 12.0 | 62.0 |
| Dust passing 80 mesh screen | 12.0 | 2.8 | 16.0 | 15.0 |
| Dust passing 40 mesh screen | 20.0 | 6.7 | 38.0 | 3.0 |
| Dust passing 10 mesh screen | 20.0 | 24.5 | 24.0 | 0.0 |
| Dust passing 4 mesh screen | 18.0 | 15.3 | 0.0 | 0.0 |
| Dust passing 2 mesh screen | 10.0 | 13.3 | 0.0 | 0.0 |
| Dust passing 1 mesh screen | 0.0 | 25.0 | 0.0 | 0.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 |
| Weight per sq. yd. 2 in. surface | 215 lbs. | 225 lbs. | 205 lbs. | 185 lbs. |

## SHEET ASPHALT PAVEMENT

Sheet asphalt is the standard asphalt pavement. Specifications call for two courses of the following composition and properties:

### BINDER OR BOTTOM COURSE

| | Limits | Standard |
|---|---|---|
| Bitumen | 5½%— 8% | 6.0% |
| Mineral passing 200 mesh | 7 —12 | 8.0 |
| Mineral passing 80 mesh | 10 —20 | 12.0 |
| Mineral passing 40 mesh | 10 —20 | 15.0 |
| Mineral passing 10 mesh | 7 —20 | 13.0 |
| Mineral passing 4 mesh | 10 —20 | 17.0 |
| Mineral passing 2 mesh | 10 —20 | 16.0 |
| Mineral passing 1 mesh | 10 —20 | 13.0 |
| | | 100.0 |
| Thickness | | 1½ in. |
| Density | | over 2.30 |

### TOP COURSE

| | Limits | Standard |
|---|---|---|
| Bitumen | 9.75%—11.0% | 10.0% |
| Mineral passing 200 mesh | 12 —18 | 13.0 |
| Mineral passing 80 mesh | 20 —34 | 23.0 |
| Mineral passing 40 mesh | 20 —40 | 27.5 |
| Mineral passing 10 mesh | 12 —35 | 26.5 |
| Mineral passing 4 mesh | 0 | 0.0 |
| Mineral passing 2 mesh | 0 | 0.0 |
| Mineral passing 1 mesh | 0 | 0.0 |
| | | 100.0 |
| Thickness | | 1½ in. |
| Density | | over 2.17 |

## MATERIALS REQUIRED FOR 1000 YARDS OF ASPHALTIC CONCRETE PAVEMENT ARE AS FOLLOWS (Typical):

| For wearing surface | | For concrete base (6 inches of 1:3:6 mix) | |
|---|---|---|---|
| "Chats" or Gravel | = 32 tons | Cement | = 732 sacks=183 barrels |
| Sand (Coarse) | = 32 tons | Sand | = 77 cubic yards |
| Sand (Fine) | = 32 tons | Rock | = 155 cubic yards |
| Dust | = 7 tons | Water | = 7,000 gallons |
| Asphaltic cement | = 8½ tons | | |

## RELATION OF THE DEFECTS OF AN ASPHALT PAVEMENT TO ITS PHYSICAL PROPERTIES

**Cracking** is caused by asphaltic cement without sufficient ductility, with too low penetration, insufficient in quantity or that has been over-heated; Imperfections in the base, such as a cracking in the base or the lack of a rigid base or lateral support; Insufficient compression when laid; Lack of traffic.

**Disintegration and Hole Formation** are caused by asphaltic cement with poor ductility and cementing value, or insufficient to coat mineral aggregate and fill voids; Dirty sand; Non-uniform thickness of surface mixture; Weak foundations in spots; Water from beneath.

**Scaling of the Surface Mixture** is caused by asphaltic cement lacking in cementing power, insufficient in quantity or subject to decomposition by the weather; Improper grading of mineral, particularly insufficient dust; Dirt conglomerates in sand; Insufficient density.

**Waviness and Displacement** are caused by asphaltic cement without cementing power, too soft or in too large quantity; Irregularity of surface thickness, or of composition of asphaltic surface mixture; Insufficient dust or filler; Non-rigid base or expansion of the base; Street with heavy grade.

**Marking** is caused by asphaltic cement that is too soft or in too large quantity; and that is too uniform; Insufficient dust or filler; Insufficient density.

## FUNCTIONS OF VARIOUS CONSTITUENTS OF ASPHALTIC SURFACE MIXTURE.

Gravel and Coarse Sand in proper relation diminish voids, insure greater stability and increase density, allow the use of less asphaltic cement, decrease tendency to displacement, waviness and marking, increase susceptibility to damage by erosion and abrasion.

Sand in proper relation increases stability by filling voids in stone, increases capacity to resist abrasion, diminishes tendency to raveling.

Filler or Very Fine Dust in proper relation increases density and stability by filling voids in sand, increases capacity to resist abrasion, allows wider range in penetration of A.C., diminishes or overcomes tendency to marking, displacement and waviness, increases cementition of mixture, increases capacity for A.C., increases the need for much compression and softer A.C. in laying mixture, eliminates lakes of A.C., decreases brittleness of pavement.

A.C. in proper quantity and relation cements mineral particles together, keeps out water, imparts pliability, resiliency and noiselessness, prevents erosion and disintegration of coarse mineral of pavement.

# Specifications for Asphaltic Cement for Asphalt Surface Mixture

**Impurities.**

The asphaltic cement shall contain no water, decomposition products, granular particles or other impurities, and it shall be homogeneous.

Ash passing the 200-mesh screen shall not be considered an impurity, but if greater than 1% corrections in gross weights shall be made to allow for the proper percentage of bitumen.

**Specific Gravity.**

The specific gravity of the asphaltic cement shall not be less than 1.000 at 77°F.

**Fixed Carbon.**

The fixed carbon shall not be greater than 18%.

**Solubility in Carbon Bisulphide.**

The asphaltic cement shall be soluble to the extent of at least 99% in chemically pure carbon bisulphide at air temperature and based upon ash free material.

**Solubility in Carbon Tetrachloride.**

The asphaltic cement shall be soluble to the extent of at least 98.5% in chemically pure carbon tetrachloride at air temperature and based upon the ash free material.

**Melting Point.**

The melting point shall be greater than 128°F and less than 160°F (General Electric method).

**Flash Point.**

The flash point shall be not less than 400°F by a closed test.

**Penetration.**

The asphaltic cement shall be of such consistency that at a temperature of 77°F a No. 2 needle weighted with 100 grams in five seconds shall not penetrate more than 9.0 nor less than 5.0 millimeters. For asphaltic cement containing ash 0.2 millimeter may be added for each 1.0% of ash to give the true penetration.

**Loss by Volatilization.**

The loss by volatilization shall not exceed 2%, and the penetration after such loss shall be more than 50% of the original penetration. The ductility after heating as above shall have been reduced not more than 20%, the value of the ductility in each case being the number of centimeters of elongation at the temperature at which the asphaltic cement has a penetration of 5.0 millimeters. The volatilization test shall be carried out essentially as follows:

Fifty grams of the asphaltic cement in a cylindrical vessel 55 millimeters in diameter and 35 millimeters high shall be placed in an electrically heated oven at a temperature of 325°F and so maintained for a period of 5 hours. The oven shall have one vent in the top 1 centimeter in diameter, and the bulb of the thermometer shall be placed adjacent the vessel containing the asphaltic cement.

**Ductility.**

When pulled vertically or horizontally by a motor at a uniform rate of 5 centimeters per minute in a bath of water, a cylinder of asphaltic cement 1 centimeter in diameter at a temperature at which

its penetration is 5 millimeters shall be elongated to the extent of not less than 10 centimeters before breaking.

## EPITOME OF THE PURPOSES OF CERTAIN SPECIFICATIONS FOR ASPHALTIC CEMENT.

**Impurities** are a measure of the care with which the asphaltic cement has been refined and handled. Usually the presence of impurities in large quantities indicates a poor grade of asphalt. Water as an impurity would act as a diluent and would cause foaming in the kettle. Ash or mineral matter is not considered an impurity if it is a natural constituent of the asphaltic cement, but the mix and cementing value must be figured on the bitumen alone.

**Specific Gravity** of the asphaltic cement should be over 1.000. The advantage of a specific gravity more than 1.000 is that there will be less tendency for water to float out the asphaltic cement. The specific gravity is raised by the presence of mineral matter. Asphaltic oils of a penetration satisfactory for paving purposes always have a specific gravity greater than 1.000. Paraffin base oil and air-blown products usually have a specific gravity less than 1.000.

**Fixed Carbon** is a measure of the chemical constitution of an asphalt to some extent. Certain types of asphalt such as Mexican have naturally a constitution that yields a large amount of fixed carbon. Fixed carbon is largely used for determining the source and uniformity of an asphalt. Fixed carbon is not free carbon, but includes free carbon, which is practically absent in asphaltic cements.

**Solubility in Carbon Bisulphide** is a measure of the purity of an asphaltic cement. The cementing value, other things being equal, is proportional to the carbon bisulphide solubility. Any carbonaceous material such as coal tar or pitch is detected by the carbon bisulphide solubility test.

**Solubility in Carbon Tetrachloride** is very nearly the same as the solubility in carbon bisulphide. It is claimed that an asphalt having more than 1½% difference in the solubility in carbon bisulphide and carbon tetrachloride has been subjected to excessive heat in refining.

**Melting Point** is the temperature at which the asphaltic cement will flow readily. The melting point desired is dependent upon the mixture. If the amount of fine dust in the mineral aggregate is low, the asphalt should have a melting point higher than the highest temperature to which the pavement is subjected.

**Flash Point** is a measure of the amount of volatile hydrocarbons that are present in the asphalt and its readiness to decompose by heat.

**Penetration** is a measure of the consistency of the asphaltic cement. It is merely a quick, convenient test for checking up numerous individual samples. The penetration is expressed in degrees and in accordance with the method of the American Society for Testing Materials, each degree representing 1/10 of a millimeter or 1/250 of an inch. The penetration, then, is the number of degrees that a No. 2 sewing needle when weighted with 100 grams will pass vertically into the A. C. at a temperature of 77°F (25°C) in 5 seconds. The penetration to be desired will depend upon the climate, the nature of the traffic, the grading of the mineral particles, the amount of voids, the amount of compression attainable, the ductility and cementing strength of the A. C. and the amount of dust filler.

**Loss by Volatilization** is a measure of the amount of light hydro-

carbons that are present in asphalt and is also a measure of the tendency of an asphalt to oxidize and to lose its ductility and penetration. Asphaltic cement which has no ductility after this volatilization test will not be satisfactory for paving purposes.

**Ductility** is the measure of the ability of an asphaltic cement to expand and contract without breaking or cracking. The same asphalt at a higher penetration should have a higher ductility, so all ductility tests should be based on a certain definite penetration regardless of the temperature, or should be based upon a temperature of 32°F. Ductility is also a measure of the cementing strength.

**Viscosity** is a measure of ability of the asphaltic cement to impart plasticity and malleability.

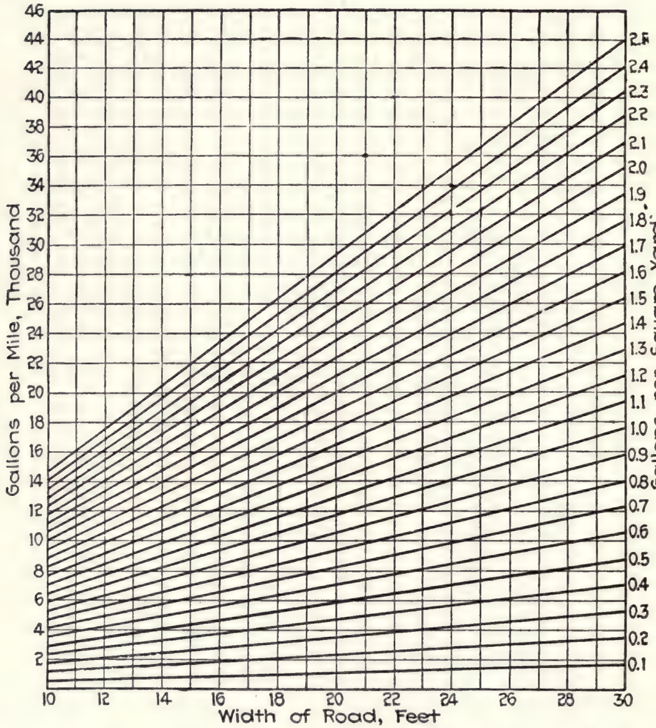
## EFFECT OF MINERAL MATTER ON THE PENETRATION OF ASPHALTIC CEMENT (Typical Case).

| % Dust | Penetration | Melting Point |
|---|---|---|
| 0 | 200 | 100 |
| 35 | 128 | 110 |
| 55 | 92 | 120 |
| 70 | 34 | 150 |

In a general way, 1% of dust in asphaltic cement decreases the penetration 2 points with A. C. of ordinary penetration. This will vary somewhat according to the character of the asphaltic cement. A pavement having a relation of 2 parts dust and 1 part bitumen cannot soften or flow in hot weather.

## FLUXING OF HARD ASPHALT.

As a general rule, 30% of 10-12°Be′ asphaltic flux is required to bring Trinidad asphalt to a penetration of 50. Less of paraffin flux is required. For each 1% of asphaltic flux added to about 50° asphalt the penetration is raised 3 points. For exact results a test should be made with the actual materials in question.




GALLONS OF ROAD OIL REQUIRED PER MILE OF ROAD
AT GIVEN WIDTH AND RATE

# Table for Calculating Voids in Sand and Hard Limestone

| Weight in Pounds per Cubic Foot | % Voids | Weight in Pounds per Cubic Foot | % Voids |
|---|---|---|---|
| 60 | 63.9 | | |
| 61 | 63.3 | 96 | 42.2 |
| 62 | 62.6 | 97 | 41.6 |
| 63 | 62.1 | 98 | 41.0 |
| 64 | 61.5 | 99 | 40.4 |
| 65 | 60.9 | 100 | 39.8 |
| 66 | 60.3 | 101 | 39.2 |
| 67 | 59.6 | 102 | 38.6 |
| 68 | 59.1 | 103 | 38.0 |
| 69 | 58.5 | 104 | 37.4 |
| 70 | 57.9 | 105 | 36.7 |
| 71 | 57.3 | 106 | 36.2 |
| 72 | 56.7 | 107 | 35.6 |
| 73 | 56.0 | 108 | 35.0 |
| 74 | 55.4 | 109 | 34.4 |
| 75 | 54.8 | 110 | 33.8 |
| 76 | 54.2 | 111 | 33.2 |
| 77 | 53.6 | 112 | 32.5 |
| 78 | 53.0 | 113 | 32.0 |
| 79 | 52.4 | 114 | 31.4 |
| 80 | 51.8 | 115 | 30.7 |
| 81 | 51.2 | 116 | 30.2 |
| 82 | 50.6 | 117 | 29.6 |
| 83 | 50.0 | 118 | 28.9 |
| 84 | 49.4 | 119 | 28.3 |
| 85 | 48.8 | 120 | 27.8 |
| 86 | 48.2 | 121 | 27.2 |
| 87 | 47.6 | 122 | 26.6 |
| 88 | 47.0 | 123 | 26.0 |
| 89 | 46.4 | 124 | 25.4 |
| 90 | 45.8 | 125 | 24.7 |
| 91 | 45.2 | 126 | 24.1 |
| 92 | 44.6 | 127 | 23.5 |
| 93 | 44.0 | 128 | 22.9 |
| 94 | 43.4 | 129 | 22.3 |
| 95 | 42.8 | 130 | 21.7 |

Grams per 100 cc $\times$ .6243 = pounds per cubic foot.
% voids = 100 — (0.376 $\times$ grams per 100 cc).

# Typical Specifications for Wearing Surface of Asphaltic Concrete

The wearing surface shall be composed of a properly prepared mixture of bitumen, dust, sand and chats, gravel or trap rock.

The amount of asphaltic cement, dust, sand and chats shall be so regulated that the average mixture shall be within the following limits by weight:

| | Size of Opening, In. Square | Lower Limit | Upper Limit | Average Typical |
|---|---|---|---|---|
| Bitumen.................... | | 7.0% | 10.0% | 8.0% |
| Dust passing 200 mesh..... | 0.0029 | 8.0 | 18.0 | 12.0 |
| Sand passing 80 mesh..... | 0.0068 | 10.0 | 20.0 | 12.0 |
| Sand passing 40 mesh..... | 0.0150 | 15.0 | 25.0 | 20.0 |
| Sand passing 10 mesh..... | 0.065 | 15.0 | 40.0 | 20.0 |
| Sand passing 4 mesh..... | 0.185 | 10.0 | 22.0 | 20.0 |
| Sand passing 2 mesh..... | 0.380 | 0.0 | 10.0 | 8.0 |

Ordinarily this mixture is to be obtained by the use of rock, coarse sand, fine bank sand and limestone dust or cement.

All of the mineral ingredients except the dust shall be heated and mixed in a suitable drier to a temperature of from 300 to 350°F. The bin containing the mineral shall be permanently equipped with a recording or an observation thermometer.

The asphaltic cement shall be added after it has been heated to a temperature not exceeding 360°F. The heating of the asphaltic cement must be by steam or if by direct fire vigorous mechanical stirring must be used. A recording thermometer should be used in the A. C. kettle and the aggregate.

The dust shall be added dry to each batch separately prior to the addition of the A. C. All materials shall be weighed.

The mixing shall be for a sufficient time to thoroughly and uniformly mix all materials and for a period of not less than one minute.

The temperature of the mixture shall be between 270°F and 350°F when it leaves the plant.

It shall be between 250°F and 350°F on the street (preferably 300°F).

The surface of the concrete shall be dry and clean at the time the surface mixture is applied.

The mixture shall be applied and raked to a uniform thickness, none being allowed to remain at the point of dumping and all lumps being thoroughly raked out.

The amount of hot mix applied shall be at least 210 pounds per square yard and shall be of a uniform thickness of 2 inches after rolling.

The compression shall be applied with a 5-ton roller until complete and sufficient in the judgment of the inspector and as indicated by the tests of the preceding day's laid surface. Hydraulic cement may be dusted over and rolled into the finished pavement.

The specific gravity of the compressed surface mixture shall average 2.20 or more and shall not at any time be less than 2.16. A piece of the compressed surface mixture after being placed in water for 24 hours shall not have absorbed water and shall not have become crumbly or weakened.

# Kansas State Highway Commission Specifications for Road Oil

## SPECIFICATION "A."

### Road Oil for the Surface Treatment of Earth Roads. (Cold Application.)

The road oil shall be homogeneous and free from water. It shall conform to the following requirements:

Specific gravity, 25°C/25°C (77°F/77°F)..Not less than 0.910
Specific viscosity at 40°C (104°F).........10.0 to 25.0
Loss at 163°C (325°F), 5 hours...........Not over 25.0%
Total bitumen..........................Not less than 99.5%
Per cent of total bitumen insoluble in 86°
B. Naphtha..........................Not less than 5.0%
Fixed carbon...........................Not less than 4.0%

## SPECIFICATIONS "B."

### Road Oil for the Surface Treatment of Earth Roads. (Cold Application.)

The road oil shall be homogeneous and free from water. It shall conform to the following requirements:

Specific gravity, 25°C/25°C (77°F/77°F)..Not less than 0.890
Specific viscosity at 40°C (104°F).........10.0 to 25.0
Total bitumen..........................Not less than 99.5%
Percentage of residue of 100 penetration...40 to 60

## SPECIFICATION "M1" ASPHALT BINDER.

The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

Specific gravity, 25°C/25°C(77°F/77°F).Not less than 1.040
Flash point..........................Not less than 163°C (325°F)
Penetration at 25°C (77°F) 100 gm. 5 sec.
When total bitumen is more than 90%.110 to 140
When total bitumen is 80% to 90%.... 90 to 120
When total bitumen is less than 80%.. 80 to 100
Loss at 163°C (325°F), 5 hours........Not over 4.0%
Penetration of residue at 25°C (77°F)
100 gms. 5 sec.
When total bitumen is more than 80%. Not less than 50
When total bitumen is less than 80%...Not less than 40
Total bitumen:
Bermudez products.................Not less than 95.0%
Cuban products....................Not less than 80.0%
Trinidad products..................Not less than 65.0%
Per cent of total bitumen insoluble in
86° B. Naphtha.....................15.0 to 28.0
Fixed carbon......................... 8.0% to 14.0%

**Brittleness Test.**—A cylindrical prism of the asphalt 1 centimeter in diameter after being maintained at a temperature of 5°C (41°F) for 20 minutes shall bend 180° at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten seconds.

## SPECIFICATIONS "M2" ASPHALT BINDER.

The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 1.020 to 1.080 |
| Flash point | Not less than 163°C (325°F) |
| Ductility at 25°C (77°F) | Not less than 50 cm |
| Penetration at 25°C (77°F) 100 gm. 5 sec. | 110 to 140 |
| Loss at 163°C (325°F) 5 hrs | Not over 3% |
| Penetration of residue at 25°C (77°F) 100 gms. 5 sec | Not less than 50 |
| Total bitumen | Not less than 99.5% |
| Per cent of total bitumen insoluble in 86° B. Naphtha | 15.0 to 28.0 |
| Fixed carbon | 9.0% to 17.0% |

**Brittleness Test.**—A cylindrical prism of the asphalt 1 centimeter in diameter after being maintained at a temperature of 5°C (41°F) for twenty (20) minutes shall bend 180° at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten seconds.

## SPECIFICATIONS "M3" ASPHALT BINDER.

The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 0.970 to 1.020 |
| Flash point | Not less than 200°C (392°F) |
| Ductility at 25°C (77°F) | Not less than 15 cm |
| Penetration at 25°C (77°F) 100 gm. 5 sec. | 80 to 100 |
| Loss at 163°C (325°F) 5 hrs | Not over 2.0% |
| Penetration of residue at 25°C (77°F) 100 gms. 5 sec | Not less than 50 |
| Total bitumen | Not less than 99.5% |
| Per cent of total bitumen insoluble in 86° B. Naphtha | 19.0% to 27.0% |
| Fixed Carbon | 8.0% to 14.0% |

**Brittleness Test.**—A cylindrical prism of the asphalt 1 centimeter in diameter after being maintained at a temperature of 5°C (41°F) for twenty (20) minutes shall bend 180° at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten seconds.

## SPECIFICATIONS "MT" REFINED TAR BINDER.

The refined tar shall be homogeneous and free from water. It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C (77°F) | 1.180 to 1.260 |
| Float test 50°C (122°F) | 110 sec. to 150 sec. |
| Total distillate by weight: | Not over |
| To 170°C (338°F) | 1.0% |
| To 300°C (572°F) | 15.0% |
| Specific gravity to total distillate 25°C (77°F) | Not less than 1.030 |
| Melting point of residue | Not over 75°C (167°F) |
| Solubility in carbon disulphide | 77.0% to 88.0% |
| Inorganic matter (ash) | Not over 0.5% |

## SPECIFICATIONS "ST1"

**Refined Tar for Surface Treatment of Bituminous or Water-Bound Macadam Roads.**

**(Hot Application.)**

The refined tar shall be homogeneous and free from water. It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 1.180 to 1.250 |
| Float test 32°C (90°F) | 90 seconds to 150 seconds |
| Total distillate by weight: | Not over |
| To 170°C (338°F) | 1.0% |
| To 300°C (572°F) | 25.0% |
| Specific gravity of total distillate 25°C (77°F) | Not less than 1.030 |
| Melting point of residue | Not over 75°C (167°F) |
| Solubility in carbon bisulphide | 78.0% to 88.0% |
| Inorganic matter (ash) | Not over 0.5% |

## SPECIFICATIONS "ST2"

**Refined Tar for Surface Treatment of Bituminous or Water-Bound Macadam Roads.**

**(Cold Application.)**

The refined tar shall be homogeneous and shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 1.120 to 1.200 |
| Specific viscosity at 40°C (104°F) | 4.0 to 12.0 |
| Total distillate by weight: | Not over |
| To 170°C (338°F) | 5.0% |
| To 300°C (572°F) | 35.0% |
| Specific gravity of total distillate 25°C (77°F) | Not less than 1.010 |
| Melting point of residue | Not over 65°C (149°F) |
| Solubility in carbon disulphide | 88.0% to 96.0% |
| Inorganic matter (ash) | Not over 0.5% |

## SPECIFICATIONS "S1."

**Heavy Oil for Surface Treatment of Bituminous or Water-Bound Macadam Roads.**

**(Hot Application.)**

The road oil shall be homogeneous, free from water and shall not foam when heated to 150°C (302°F). It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | Not less than 0.980 |
| Flash point | Not less than 150°C (302°F) |
| Specific viscosity to 100°C (212°F) | 30.0 to 70.0 |
| Float test at 50°C (122°F) | 100 seconds to 20 seconds |
| Loss at 163°C (325°F) 5 hrs | Not over 5.0% |
| Float test of residue at 50°C (122°F) | 120 seconds to 240 seconds |
| Total bitumen | Not less than 99.5% |
| Per cent of total bitumen insoluble in 86°B Naphtha | 10.0 to 25.0% |
| Fixed carbon | 7.0% to 15.0% |

## SPECIFICATIONS "S2."

**Medium Oil for Surface Treatment of Bituminous or Water-Bound Macadam Roads.**

**(Hot Application.)**

The road oil shall be homogeneous, free from water and shall not foam when heated to 100°C (212°F). It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 0.960 to 1.010 |
| Flash point | Not less than 100°C (212°F) |
| Specific viscosity to 100°C (212°F) | 5.0 to 15.0 |
| Float test at 32°C (90°F) | 30 seconds to 90 seconds |
| Loss at 163°C (325°F) 5 hrs | Not over 15.0% |
| Float test of residue at 50°C (122°F) | 90 seconds to 180 seconds |
| Total bitumen | Not less than 99.5% |
| Per cent of total bitumen insoluble in 86°B Naphtha | 7.0 to 20.0% |
| Fixed carbon | 5.0% to 10.0% |

## SPECIFICATIONS "S3"

**Light Oil for Surface Treatment of Bituminous or Water-Bound Macadam or of Gravel Roads.**

**(Cold Application.)**

The road oil shall be homogeneous and free from water. It shall conform to the following requirements:

| | |
|---|---|
| Specific gravity 25°C/25°C (77°F/77°F) | 0.920 to 0.970 |
| Specific viscosity at 25°C (77°F) | 30.0 to 70.0 |
| Loss at 163°C (325°F) 5 hrs | 20.0% to 30.0% |
| Total bitumen | Not less than 99.5% |
| Per cent of total bitumen insoluble in 86°B Naphtha | 5.0 to 20.0 |
| Fixed carbon | 4.0% to 10.0% |

## ASPHALT FILLER FOR BRICK.
(Mexican Type for Vertical Fiber Brick.)

The joints between the paving blocks next the curb, railroad tracks and around manholes, or other street structures, shall be filled with asphalt filler complying with the following requirements:

The asphalt filler shall be composed of asphalt, or asphalts properly fluxed, if flux is necessary to bring it to the proper consistency. It shall contain at least 99½ per cent bitumen soluble in carbon bisulphide. At least 99½ per cent of the contained bitumen soluble in carbon bisulphide shall be soluble in cold carbon tetrachloride.

The penetration shall conform to the following:

No. 2 Needle 5 Sec. 100 Grammes at 77°F 25 to 35.
No. 2 Needle 1 Min. 200 Grammes at 32°F not below 10.
No. 2 Needle 5 Sec. 50 Grammes at 115°F not above 90.

The above filler shall be waterproof, shall adhere strongly to the brick, both in the joints and on the surface, and shall remain ductile and pliable at all climatic temperatures to which it may be subjected. It shall not run in the joints during the hottest summer weather, nor become hard or brittle when cold.

The melting point shall not be less than 165°F nor more than 200°F. The brick shall be dry and the asphalt filler shall be poured at a temperature of not less than 350°, nor more than 450°F and by means of squeegees, especially adapted to the purpose, the joints shall be thoroughly filled and shall provide sufficient hot material on the top surface as will fully cover and penetrate the etched or reticular surface with a thin coat of the hot asphalt.

The minimum amount of coarse sand, clean and free from dust, necessary to keep the fresh asphalt from sticking to traffic shall be immediately applied.

## ASPHALT FILLER FOR BRICK.
(Texaco Type for Vertical Fiber.)

The joints between the paving blocks next the curb, railroad tracks and around manholes, or other street structures, shall be filled with asphalt filler complying with the following requirements:

The asphalt filler shall be composed of asphalt, or asphalts properly fuxed, if flux is necessary to bring it to the proper consistency. It shall contain at least 98 per cent bitumen soluble in carbon bisulphide. At least 98½ per cent of the contained bitumen soluble in carbon bisulphide shall be soluble in cold carbon tetrachloride.

The penetration shall conform to the following:

No. 2 Needle 5 Sec. 100 Grammes at 77°F 25 to 60.
No. 2 Needle 1 Min. 200 Grammes at 32°F not below 10.
No. 2 Needle 5 Sec. 50 Grammes at 115°F not above 200.

The above filler shall be waterproof, shall adhere strongly to the brick, both in the joints and on the surface, and shall remain ductile and pliable at all climatic temperatures to which it may be subjected. It shall not run in the joints during the hottest summer weather, nor become hard or brittle when cold.

The melting point shall not be less than 150°F nor more than 225°F. The brick shall be dry and the asphalt filler shall be poured at a temperature of not less than 375°, nor more than 450°F and by means of squeegees, especially adapted to the purpose, the joints shall be thoroughly filled and shall provide sufficient hot material

on the top surface as will fully cover and penetrate the etched or reticular surface with a thin coat of the hot asphalt.

The minimum amount of coarse sand, clean and free from dust, necessary to keep the fresh asphalt from sticking to traffic shall be immediately applied.

## ASPHALT FILLER FOR BRICK.
(Sarco Type.)

The joints between the paving blocks next the curb, railroad tracks and around manholes, or other street structures, shall be filled with asphalt filler complying with the following requirements:

The asphalt filler shall be composed of asphalt containing at least 98 per cent of bitumen soluble in carbon bisulphide. At least 98½ per cent of the contained bitumen soluble in carbon bisulphide shall be soluble in cold carbon tetrachloride. The penetration shall be uniform in consistency and shall not vary more than seven and one-half (7½) points in penetration from the following standard:

The penetration shall conform to the following:

No. 2 Needle 1 Min. 200 Grammes at 32°F 30.
No. 2 Needle 5 Sec. 100 Grammes at 77°F 40.
No. 2 Needle 5 Sec. 50 Grammes at 115°F 60.

The above filler shall be waterproof, shall adhere strongly to the brick, both in the joints and on the surface, and shall remain ductile and pliable at all climatic temperatures to which it may be subjected. It shall not run in the joints during the hottest summer weather, nor become hard or brittle when cold.

The melting point shall be not less than 225°F, nor more than 275°F. The brick shall be dry and the asphalt filler shall be poured at a temperature of not less than 375°F, nor more than 450°F, and by means of squeegees, especially adapted to the purpose, the joints shall be thoroughly filled and shall provide sufficient hot material on the top surface as will fully cover the etched or reticular surface with a thin coat of the hot asphalt.

A top dressing of one-half (½) inch of coarse sand shall be spread immediately after the filler is applied and before the same has had its initial set, and shall immediately be rolled with a roller weighing not less than three nor more than five tons until the sand is thoroughly imbedded in the asphalt filler. As soon as the sand has been thoroughly ground into the top dressing of asphalt by traffic the surplus may then be swept off clean.

# Chemical Nature of Cracking of Oil

When crude oil is subjected to ordinary distillation by fire the ht products naturally present in the oil are distilled off as such to a temperature of about 300°C (572°F) comprising both the gaso-ine and the kerosene. Above this temperature the hydrocarbons undergo partial decomposition while distilling, with the result that some light products are produced and distilled along with the heavy products. Olefins as well as paraffin compounds of lower molecular weight than the oil being heated are formed. By vigorous firing the entire oil residue may be distilled, leaving only a variable amount of residual carbon as a product of decomposition. The amount of carbon and gas formed by this pyrogenic decomposition is greater with the asphaltic or naphthene petroleums than with the paraffin base petroleums. A typical heavy Mid-Continent petroleum gives 4.5% of carbon and 4.0% of gas on distillation to coke or carbon. With pure paraffin base oils the amounts of carbon and gas formed are comparatively slight.

This property of all heavy petroleums in decomposing into hydrocarbons of lower molecular weight by heating is generally known as cracking. The chemical reactions involved in cracking are not definite. It was originally supposed that cracking involved the formation of a large amount of olefins according to the following reaction:

$$C_nH_{2n+2} = C_{n-m}H_{2(n-m)+2} + C_mH_{2m}$$

specific illustration of which would be

| | | |
|---|---|---|
| $C_{15}H_{32}$ | $=C_8H_{18}$ | $+C_7H_{14}$ |
| Pentadecane | =Octane | +Heptylene |

This reaction does not, however, accord with the facts, since gas and carbon are always formed in varying amount. A reaction which corresponds to the yields as experimentally found under certain conditions is the following:

$$2C_nH_{2n+2} = 2C_{n-m}H_{2(n-m)+2} + mCH_4 + mC$$

or as a specific illustration

| | | | |
|---|---|---|---|
| $C_{15}H_{32}$ | $=C_8H_{18}$ | $+7CH_4$ | $+7C$ |
| Pentadecane | =Octane | +Methane | +Carbon |

Yet under certain other conditions the amount of gas formed is very small, indicating that the following reaction was partly carried out.

$$(2m+2)\quad C_nH_{2n+2} = (2n+2)\quad C_mH_{2n+2} + 2(n-m)C$$

or as an illustration

| | | |
|---|---|---|
| $9C_{15}H_{32}$ | $=16\,C_8H_{18}$ | $+7C$ |
| Pentadecane | =Octane | +Carbon |

This last reaction is also indicated by the yields of gasoline obtained from some crude oils given in the table on page 120.

Pure paraffin wax of melting point of 130°F and specific gravity of 0.892 on repeated cracking confined under pressure up to 57 atmospheres at temperature of 400°C and with a vapor space twice the volume of the liquid, yielded 32.5% by volume of gasoline of 0.724=63.4°Be' gravity or 29.1% by weight by each treatment or a total of 94.7% by weight, or 104% by volume.

The amount produced on first six treatments was as follows:

| | | |
|---|---|---|
| First. . . . . . . . . . . | 29.1% | by weight of original paraffin |
| Second. . . . . . . . . | 19.9% | by weight of original paraffin |
| Third. . . . . . . . . . | 14.5% | by weight of original paraffin |
| Fourth. . . . . . . . . | 9.9% | by weight of original paraffin |
| Fifth. . . . . . . . . . | 6.8% | by weight of original paraffin |
| Sixth. . . . . . . . . . | 4.7% | by weight of original paraffin |
| | 84.9% | |

The gasoline produced consisted of paraffin hydrocarbons as shown in curve on page 227.

That the cracking of oil is not simply a decomposition of the hydrocarbon molecules is shown by the curves on pages 211-2-3. These curves show the relation between the distilling temperature and the specific gravity of water white Cabin Creek distillate. Before cracking it had an end point of about 540°F and its heaviest ends had a specific gravity of 0.815. After cracking the end point was above 640°F and the end gravity above 0.900. Both heavier and higher boiling hydrocarbons as well as lighter and lower boiling hydrocarbons were produced simultaneously. There must have been polymerization to yield hydrocarbons of both higher boiling point and higher specific gravity. By continued cracking there may be made from water white distillate, solid and ductile asphaltic cement of typical conchoidal fracture. It may be that these polymerized products will make lubricating oils if they prove to be more resistant to heat decomposition and ordinary paraffin hydrocarbons.

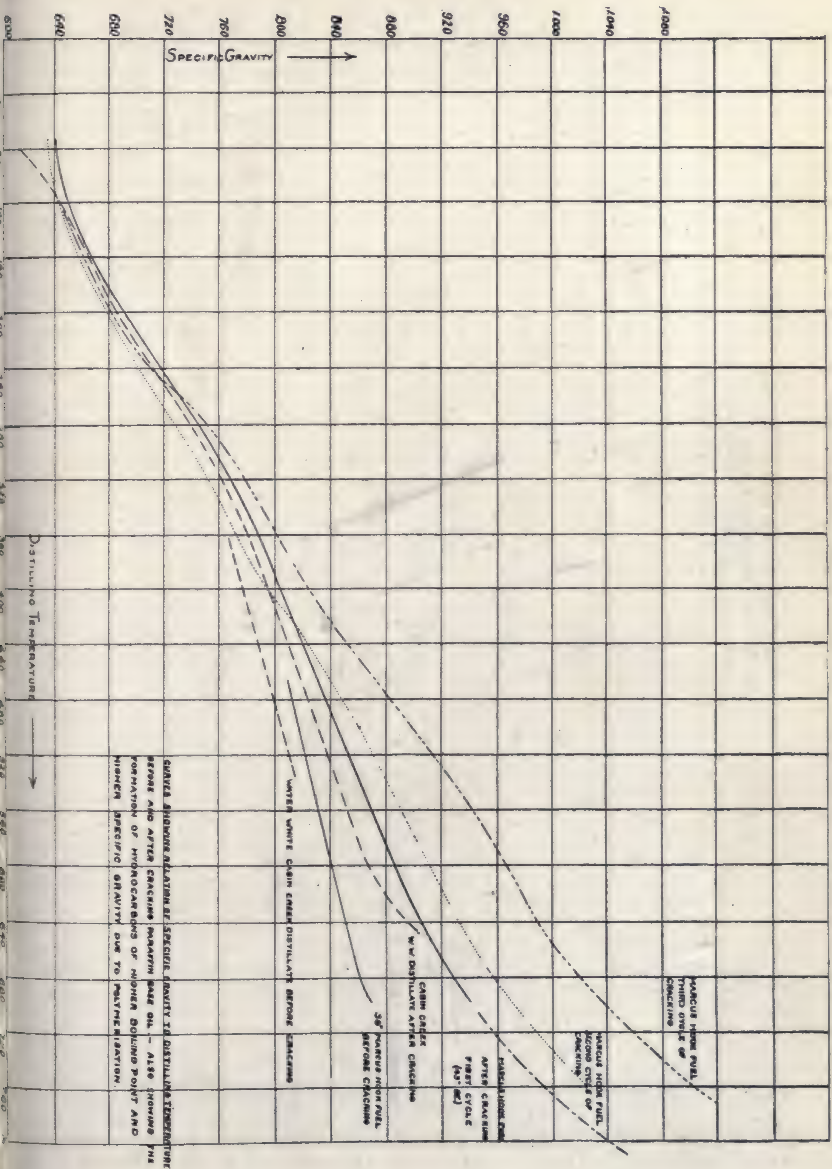
The gases produced by cracking likewise are not simple split-off hydrocarbons but vary according to the method of cracking. In liquid phase cracking the chief variation is in the olefin and hydrogen content. In a general way, there seems to be a tendency for low percentages of hydrogen to be associated with low percentages of olefins. A typical gas made in a Burton still gives the following analysis:

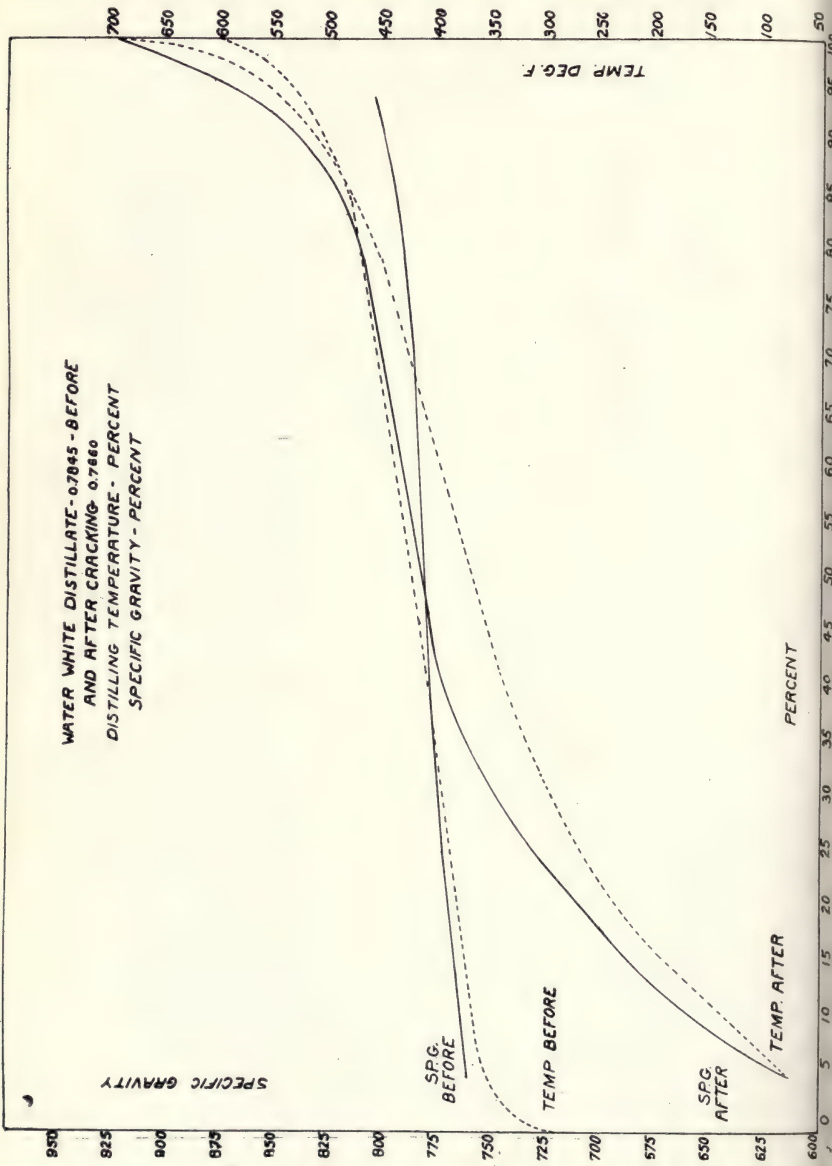
| | |
|---|---|
| Methane and ethane ( $C_nH_{2n+2}$ ) | = 82.0% |
| Olefins | = 8.5% |
| Hydrogen | = 9.5% |

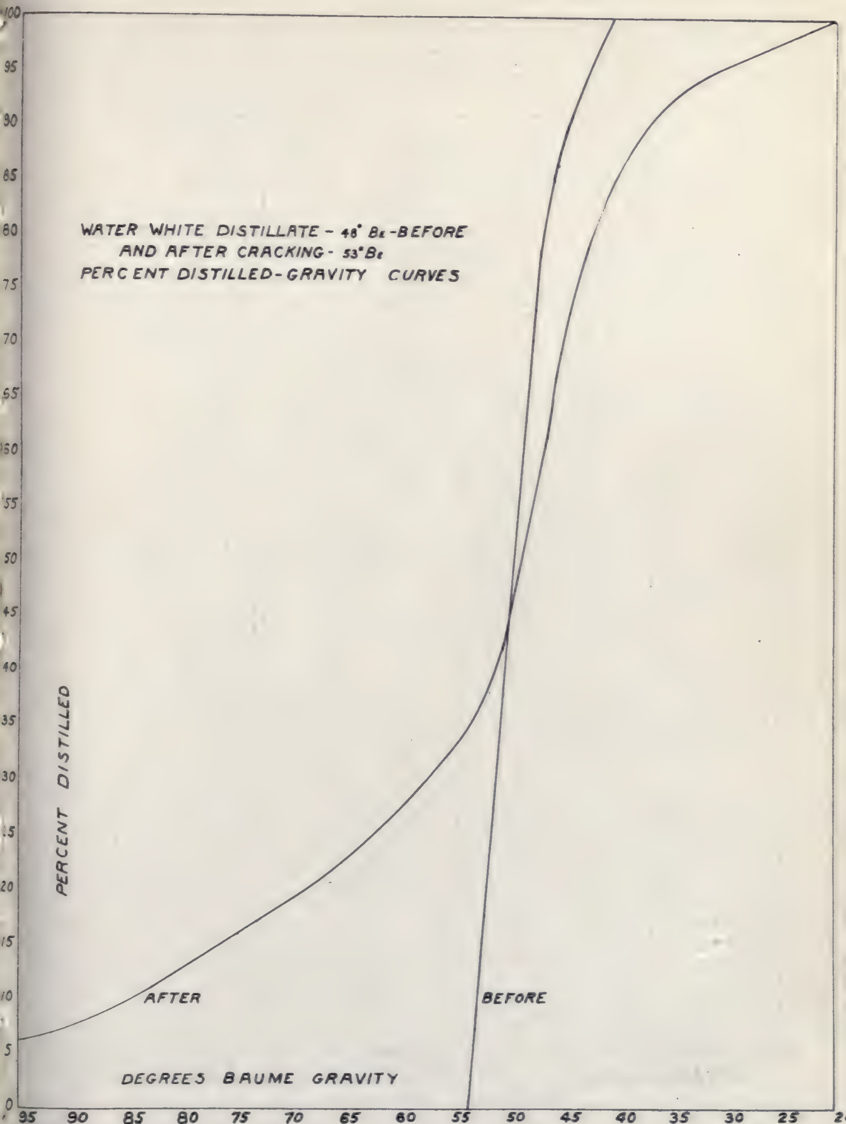
One of the problems in cracking is to limit the amount of hydrogen. This has been partially done by allowing the hydrogen to remain in contact with the cracked distillate under high pressure and at a temperature somewhat below the ordinary temperature of cracking. (See U. S. patent 1255138.)

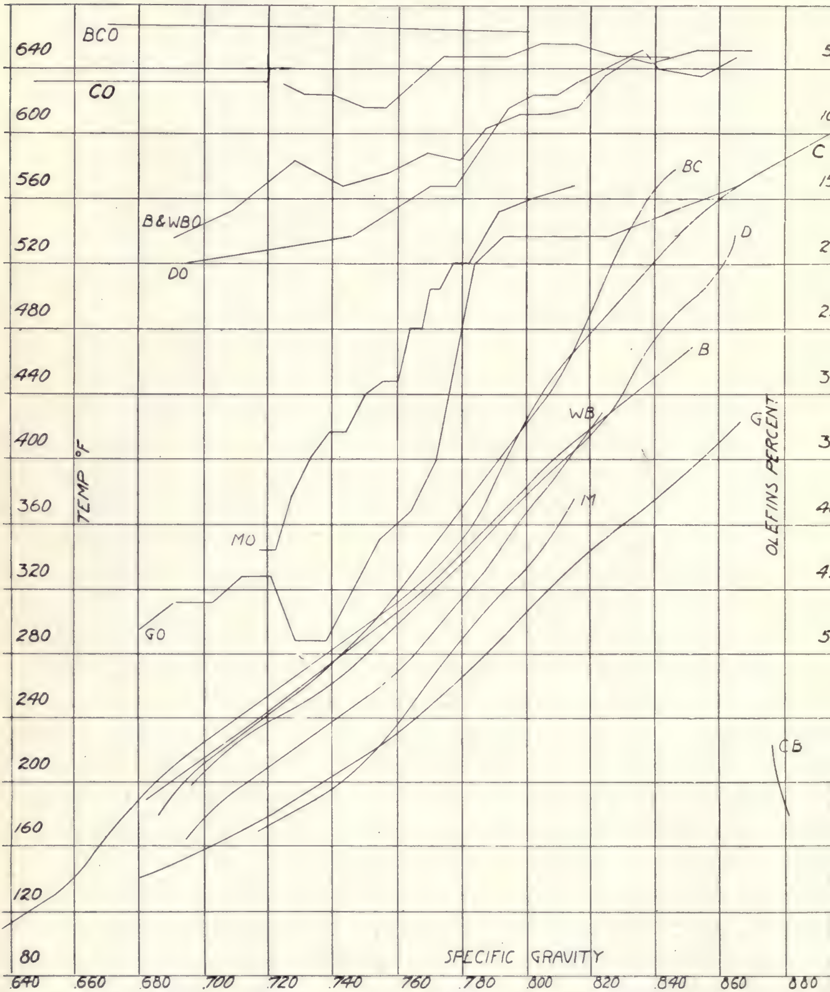
The chart on page 214 shows some of the relative properties of light hydrocarbons made by various processes used more or less in a commercial way for the production of gasoline from heavy oil. The smooth lines represent the distilling temperatures and the irregular lines represent the per cent of olefins in the fractions represented by the specific gravities indicated at the bottom of the chart. The per cent olefins or unsaturated hydrocarbons are shown at the right and the distilling temperatures are shown at the left.

The product marked B C is Burkburnett crude oil, B C O being the olefin curve. C is a gasoline made by a certain type of very high pressure equilibrium cracking in the liquid phase. W B is gasoline made by the Benton process. B and D are gasolines made by 85-170 lbs. pressure distillation. M and G are gasolines made by cracking in the liquid phase. C B is coal tar benzol as sold for blending for motor use.


SPECIFIC GRAVITY
DISTILLING TEMPERATURE
600
640
680
720
760
800
840
880
920
960
1.000
1.040
1.080
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
WATER WHITE CABIN CREEK DISTILLATE BEFORE CRACKING
CABIN CREEK W.W. DISTILLATE AFTER CRACKING
36° MARCUS HOOK FUEL BEFORE CRACKING
MARCUS HOOK FUEL AFTER CRACKING FIRST CYCLE
MARCUS HOOK FUEL SECOND CYCLE OF CRACKING
MARCUS HOOK FUEL THIRD CYCLE OF CRACKING
CURVES SHOWING RELATION OF SPECIFIC GRAVITY TO DISTILLING TEMPERATURE BEFORE AND AFTER CRACKING PARAFFIN BASE OIL.— ALSO SHOWING THE FORMATION OF HYDROCARBONS OF HIGHER BOILING POINT AND HIGHER SPECIFIC GRAVITY DUE TO POLYMERIZATION.


WATER WHITE DISTILLATE - 0.7845 - BEFORE
AND AFTER CRACKING 0.7660
DISTILLING TEMPERATURE - PERCENT
SPECIFIC GRAVITY - PERCENT
TEMP. DEG. F.
SPECIFIC GRAVITY
PERCENT
S.P.G. BEFORE
TEMP BEFORE
S.P.G. AFTER
TEMP. AFTER
700
650
600
550
500
450
400
350
300
250
200
150
100
50
950
925
900
875
850
825
800
775
750
725
700
675
650
625
600
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100


WATER WHITE DISTILLATE - 48° Bé - BEFORE
AND AFTER CRACKING - 53° Bé
PERCENT DISTILLED - GRAVITY CURVES
PERCENT DISTILLED
DEGREES BAUME GRAVITY
AFTER
BEFORE
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25




Graphic Comparison of Chemical Properties of Natural and Cracked Hydrocarbons Produced by Several Well Known Cracking Processes. (See page 210.)

# Classification of Oil Cracking Processes

**(Representative Patents)**

I. Cracking in the vapor phase.
  A Atmospheric Pressure.
    Oil gas plants—very high temperature.
    Pintsch Gas Plants—very high temperature.
    Blaugas Plants—1000-12000°F.
    Parker (W.M.) process—at 1000°F with or without steam.
    Greenstreet—Cherry red with steam.
  B With Increased Pressure.
    Rittman process—above 950°F and 200-300 lbs. pressure.
    W. A. Hall process—1100°F and about 75 lbs. pressure.

II. Cracking in the Liquid Phase.
  A With Distillation.
    1. At Atmospheric Pressure.
      Luther Atwood (1860).
      McAfee Process with aluminum chloride.
      Russian and American Practice for illuminating oils.
    2. Above Atmospheric Pressure.
      Dewar & Redwood (1890).
      Bacon & Clark at 100-300 lbs.
      Burton (Standard Oil Co.) 650-850°F and 60-85 lbs.
      Dubbs, J. A., over 10 lbs. and over 300°F.
    3. Very high pressure (over 27 atmospheres).
  B Without Distillation and with High Pressure.
    1. Without vapor space for equilibrium (continuous processes).
      Benton (1886) 700-1000°F and 500 pounds.
      Goebel-Wellman.
      Mark (English).
    2. With Vapor Space.
      (a) Intermittent.
        Palmer (below 27 atmospheres for aromatics).
      (b) Continuous.

## CATALYTIC PROCESSES

Many claims are made as to the virtue of certain substances in promoting the conversion of heavy hydrocarbons into light hydrocarbons. The writer has made many high pressure-liquid phase tests with such substances as aluminum chloride, hydrogen chloride, manganese oxide, nickel, copper, lime, mercury, sodium nitrate, aluminum powder, zinc dust, iron dust, iron oxide and platinized pumice and has found in no case either increased rates of reaction or increased yields over those obtained by heat alone under the same conditions.

Electrical processes are not considered by informed refiners on the basis of cost alone and none have yet been demonstrated as having any virtue, in fact, other than as a means of applying heat.

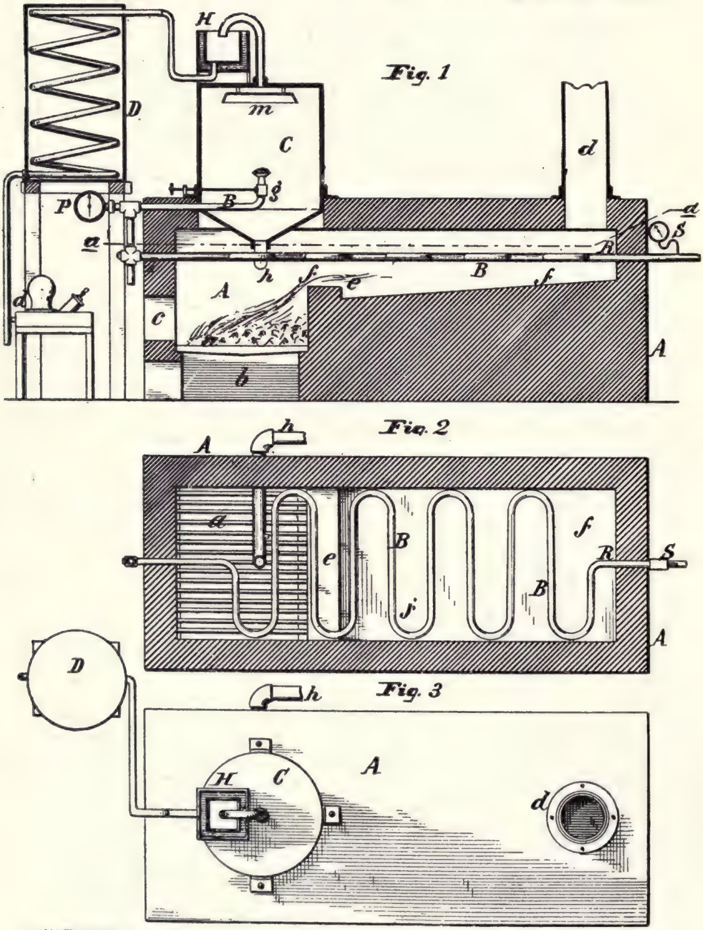
In some instances a sweeter and whiter product resulted by use of added chemicals than with heat alone.

No Model.)

# G. L. BENTON.

## PROCESS OF REFINING CRUDE PETROLEUM OIL.

No. 342,564. Patented May 25, 1886.




WITNESSES

INVENTOR

George L. Benton

By J. Walter Douglass Atty

# Development of Commercial Practice in Cracking of Oil

It has been stated that the commercial cracking of oil was accidentally discovered in the winter of 1861 by a stillman at Newark, New Jersey. However, this is probably not the case, since a patent was granted to Luther Atwood, of New York, May 15, 1860, No. 28,246, in the U. S. Patent Office, which provides for the production of light hydrocarbon illuminating oils from heavy oils, paraffin, etc. The apparatus provides for the cooling of the heavy oil vapors and their return to the still for further cracking. This is all carried out at atmospheric pressure.

The first record of pressure distillation is apparently set forth by James Young in his patent, No. 3345 (English) of 1865, in which a distillation is described as being conducted in a vessel having a loaded valve or a partially closed stop cock through which the confined vapors escape under any desired pressure. Under these conditions, distillation takes place at higher temperature than the normal boiling points of the heavy hydrocarbons and partial cracking results. The patent was taken out for treatment of shale oil and in practice a pressure of 20 pounds to the square inch was recommended.

The first extremely high pressure process was that of Benton, U. S. patent No. 342,564, May 25, 1886. In this the oil is heated at a temperature of from 700 to 1000°F through a pipe not connected with a high pressure vapor chamber, but leading to a low pressure expansion chamber. The pressure used is as high as 500 pounds per square inch.

The most important patent in the present development of cracking processes is that issued to Dewar & Redwood which is described on the following two pages.

## SPECIFICATIONS AND CLAIMS OF DEWAR & REDWOOD

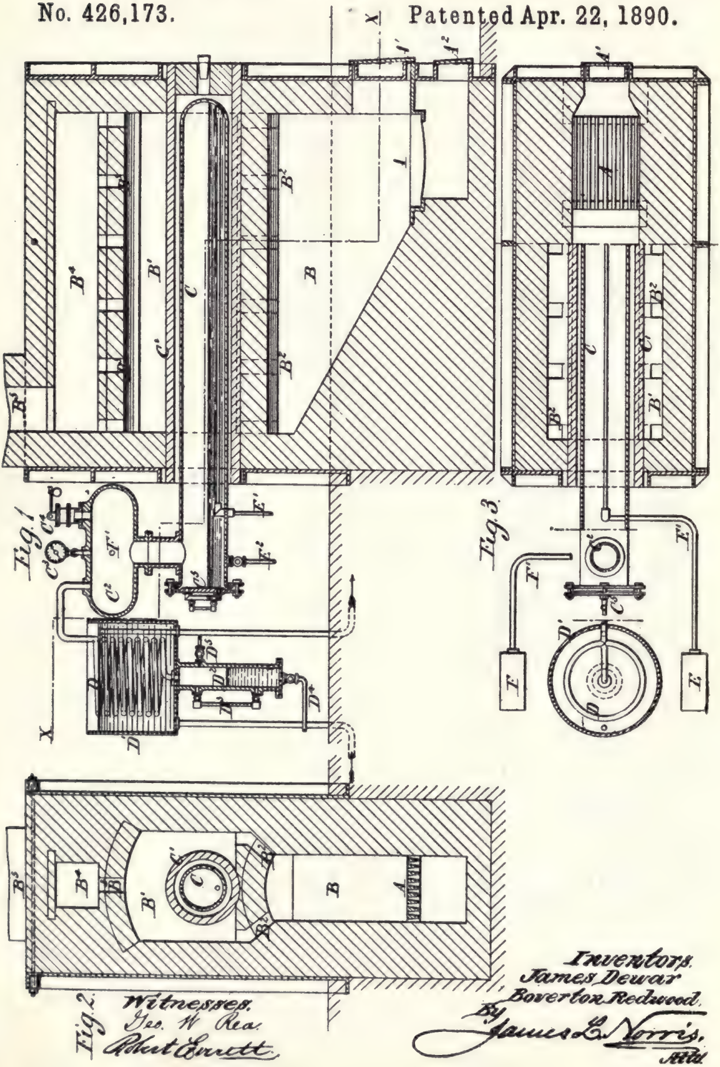
"In distilling mineral oils—such as natural petroleum or similar oil made from shale, coal or other bituminous substances—in order to separate the lighter oils, suitable for lamps and other purposes, from the heavier oils, there is frequently a very large residue of heavy oil. Attempts have been made to obtain lighter oils from such residues or from heavy natural petroleums by causing the vapor generated in the still-boiler to pass a heavily-loaded valve, so that the vaporization takes place under considerable pressure. It has also been proposed to arrange the still-boiler with its upper part cooled,

(No Model.)

J. DEWAR & B. REDWOOD.

APPARATUS FOR THE DISTILLATION OF MINERAL OILS AND LIKE PRODUCTS.

No. 426,173. Patented Apr. 22, 1890.



so that the less volatile portions of the vapor may become more or less condensed and fall back into the hot liquid below, this mode of operating being commonly termed "cracking". Both these methods are objectionable, the former on account of the irregularity of the distillation and the latter on account of the waste of heat in conducting the cracking process and the slowness and insufficiency of the results."

"Our invention relates to a method of conducting the distillation by suitable apparatus in such a manner that we get the benefit of regular vaporization and condensation under high pressure, and that we may at the same time get such advantage as can be obtained from cracking. For this purpose we arrange a suitable boiler or retort, and a condenser in free communication with one another, without interposing any valve between them; but we provide a regulated outlet for condensed liquid from the condenser. We charge and keep charged the space in the boiler or retort and condenser that is not occupied by liquid with gas under considerable pressure, it may be with air or it may be with carbonic-acid gas or other gas that cannot act chemically on the matter treated. The distillation and condensation being thus conducted under considerable pressure, which can be regulated at will, we obtain from the heavy residue a quantity of more or less light oil suitable for illuminating and other purposes, which cannot be obtained by distillation under atmospheric pressure. We may also arrange the still-head or upper part of the boiler or retort so as to operate according to the cracking method above referred to, the cracking in this case taking place under high pressure instead of being carried on under atmospheric pressure.

"The apparatus for effecting distillation in the manner described may be arranged in various ways. The accompanying drawings show one form of apparatus for this purpose.

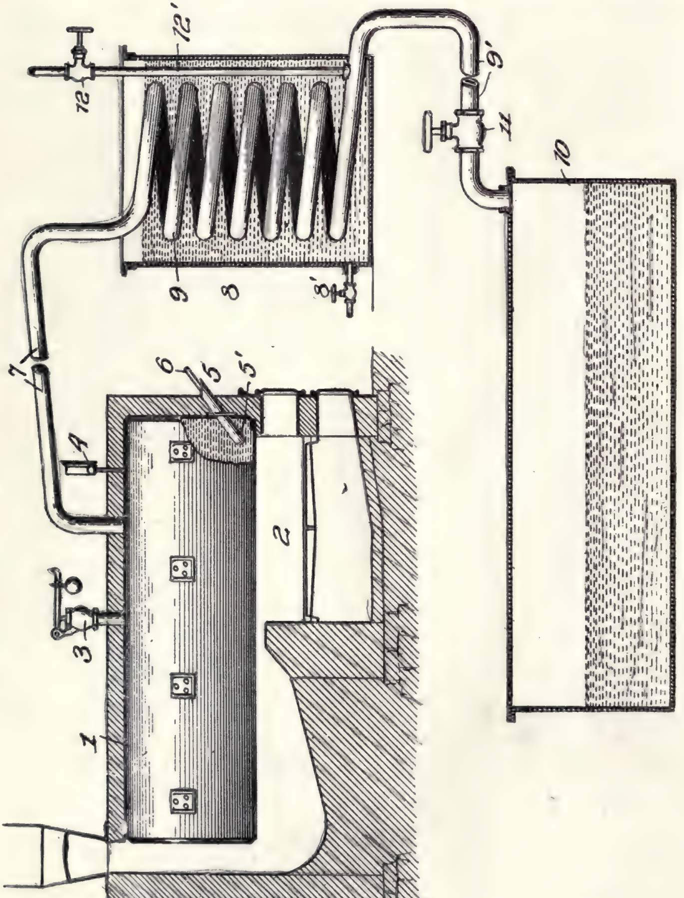
"By a pipe and cock or a suitably loaded safety-valve $D^5$ gas may be withdrawn from the space above the liquid in the column $D^2$.

"By regulating the heat and pressure to which the retort is subjected the character of the distillate may be varied, and thus oils more or less light can be obtained to suit various uses. Also the proportions of the parts may be varied, and, if necessary, means of cooling may be applied to the still-head $C^2$.

"Having thus described the nature of our invention and the manner of carrying the same into effect, we claim—the herein-described method of distilling mineral oils and like products, which consists in both vaporizing them and condensing the generated vapor under a regulated pressure of air or gas substantially as specified."

W. M. BURTON.
MANUFACTURE OF GASOLENE.
APPLICATION FILED JULY 3, 1912.

**1,049,667.** Patented Jan. 7, 1913.




Witnesses.
E. E. Gaylord
G. F. Chase

Inventor:
William M. Burton,
By Dyrenforth, Lee, Chritton & Wiles,
Att'ys.

## THE BURTON PROCESS

This is the process by which much of the artificial gasoline now on the market is made.

The sketch in the patent is shown on the opposite page.

In the practical operation of this process a very hot furnace is required on account of the very great radiation of heat from the return conduit 7.

Novelty in this process is claimed to lie in the maintenance of pressure on the condenser, though this is done in the Dewar & Redwood process already described (q.v.). The fact remains, however, that the Burton process is being successfully operated on a large scale and presumably with profit. In one of the Burton patents (1,105,961) it is claimed that 63½% of the original charge of oil is converted into gasoline.

The actual operation of the Burton process has been described as follows.

The stills have a capacity of 200 barrels each and are heavy, horizontal steel cylinders, with walls one-half inch thick, thoroughly insulated with asbestos. From the top of the still is a long run-back, exposed to the air, which returns for cracking any undecomposed oil. The stills, the run-back and the condenser are all maintained under a pressure of about 85 pounds per square inch, the oil being heated to a temperature of about 750°F. Each still is charged every 48 hours, the yield being 57% of 51° naphtha. The carbon tends to be of a granular or mealy nature, rather than hard and adherent, and is cleaned out after each run.

Important modifications of the Burton process are shown in the Clark patents, 1,119,496, 1,129,034 and 1,132,163; A. S. Hopkins, 1,199,-464; R. E. Humphreys, 1,122,002, 1,122,003 and 1,119,700.

One of the Clark modifications allows the application of heat to tubes and seeks to overcome the danger of heating a large bulk of oil directly.

The Hopkins patent provides for introducing fresh oil supply into the run-back 7.

One of the Humphreys patents provides for plates in the bottom of the still to prevent the bad effect of carbon and to give a large metallic heating area.

The original Burton claims are as follows (Patent 1,049,667, filed July 3, 1912):

"1. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling point upward of 500°F to obtain therefrom low-boiling point products of the same series, which consists in distilling at a temperature of from about 650 to about 850°F the volatile constituents of said liquid, conducting off and condensing said constituents and maintaining a pressure of from about 4 to about 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation.

2. The method of treating the liquid portions of the paraffin series of petroleum distillation having a boiling point of upward of 500°F to obtain therefrom low-boiling point products of the same series, which consists in distilling off at a temperature of from about 650 to 850°F the volatile constituents of said liquid, conducting off and condensing said constituents, maintaining a pressure of from about 4 to about 5 atmospheres on said liquid of said vapors throughout their course to and while undergoing condensation, and releasing from time to time accumulations of gas from the product of condensation."

## ADVANTAGES OF LIQUID PHASE CRACKING

All processes of making gasoline which have not involved the treatment of the oil strictly in the liquid phase are said to have met with only a questionable degree of success.

While the cracking of oil in the vapor phase would be highly desirable if the product and other conditions were satisfactory, it has been claimed by many that the advantages of applying the heat to the liquid phase are as follows:

1. A lower temperature is sufficient to induce cracking.
2. The rate of reaction is greatly increased, being greater the higher the pressure within certain limits.
3. A product containing smaller amount of olefins and aromatics is produced.
4. A higher yield of refined gasoline is obtained.
5. There is a better economy of heat.
6. There is a selective action on the oil or heavy portions of the petroleum by reason of the automatic conversion of the desired product into the vapor phase, thus freeing it from further liability to decomposition.
7. There is a high oil capacity with small plant dimensions.
8. There is a perfect control of temperature.
9. There is a rapid and more complete absorption of heat from the furnace and less tendency to local overheating on account of the much higher specific heat of oil than of the oil vapor.
10. There is the possibility of operating either by intermittent charging or by continuous treatment and distillation.
11. The carbon is deposited in a suspended condition in the oil and not on the retaining walls.
12. There is the possibility of the use of the automatically developed pressure for mechanical and condensing purposes. The chief disadvantage in cracking oil in the vapor phase and under high pressure seems to be the danger attendant upon a possible failure of steel parts. (See page 225.)

# Refinery Engineering Data on Distilling and Cracking of Petroleum

The total capacity of a horizontal still is approximately 0.14 $d^2l$, d being the diameter and l the length of the still in feet.

The heating area of a horizontal still is 1.0472 d l on the assumption that one-third of the shell is fired. In continuous stills a larger area may be fired on account of a higher minimum oil level.

Continuous stills give a greater crude oil capacity than batch stills on account of the time required for charging and discharging batch stills. The amount of benzine or crude gasoline distilled is 1.5 d l barrel per day with continuous operation and with no other products distilled.

The approximate amount of gasoline from crude oil stills per day per square foot of still bottom area not including charging time or time for bringing to distillation temperature is 1.0 barrel. This may vary according to the intensity of firing and the character of the crude.

The approximate total fuel consumption in producing one gallon of 58°Be′ gasoline in a still by cracking at 85 pounds pressure is 50,000 B. T. U. or 0.4 gallon of fuel oil.

The approximate total fuel consumption by properly cracking in tubes at 750 pounds pressure in producing one gallon of 58° Be′ gasoline is 20,000 B. T. U. or 0.15 gallon of fuel oil.

The report of the Western Petroleum Refiner's Association of September, 1919, on a pressure distillation process operating at 135 pounds per square inch pressure may be analyzed as follows:

0.164 gallon of 58°Be′ gasoline was produced per square foot of heating area per hour after the oil was brought to the cracking temperature.

0.8 gallon of fuel oil equivalent to 112,000 B. T. U. was required to produce 1 gallon of 58°Be′ gasoline.

200 cubic feet of gas was produced for each barrel of 58°Be′ gasoline.

7.0 pounds of still carbon was produced per barrel of 58°Be′ gasoline.

A typical composition of the so-called carbon deposited in cracking stills is as follows. This sample was extracted with 70°Be′ petroleum naphtha before testing:

| | |
|---|---|
| Moisture (volatile at 105°C)... | 0.00% |
| Volatile (500°C)............. | 13.08% |
| Fixed carbon................. | 80.42% |
| Ash.......................... | 6.50% |
| | 100.00% |
| Sulphur...................... | 1.83% |
| Iron......................... | 2.76% |

The following data represents the operation covering a long period of time of a very extensively used process for cracking oil, based on one still.

| | |
|---|---|
| Gallons of oil charged...................... | 8,000 gallons |
| Gallons of oil run in....................... | 1,800 gallons |
| Gallons of oil treated...................... | 9,800 gallons |

| | |
|---|---|
| Average time feeding in oil | 15 hours |
| Total hours distilled | 37 hours |
| Pounds of coal used to distill | 11,000 lbs. per run |
| Total distillate produced | 5,295 gallons |
| Total 58.5° gasoline produced | 3,018 gallons |
| % distillate | 54.04% |
| % 58.5° gasoline in distillate | 57.0% |
| % 58.5° gasoline of oil treated | 30.8% |
| Amount of distillate per hour of distilling | 143.1 gallons |
| % distillate of total charge per hour of distillation | 1.46% |
| Amount of 58.5°Be′ gasoline per hour of distilling | 81.6 gallons |
| % of 58.5° gasoline per hour of distilling | 0.83% |
| Area of still bottom | 270 sq. ft. |
| Gallons of 58.5° gasoline per hour per sq. ft. of heating area | 0.302 |
| Lbs. of coal per gallon of gasoline (58.5°) | 3.625 lbs. |
| Equivalent gallons of fuel oil per gallon of 58.5° gasoline | 0.25 |

## CALCULATION OF HEAT EXCHANGES IN REFINERY CONDENSERS

In calculating amount of water required for condenser, use the following formula:

$$w = \frac{200\ g}{t_2 - t_1}$$

$w$ = gallons of water required per hour.
$t_1$ = incoming temperature of condenser water.
$t_2$ = outgoing temperature of condenser water.
$g$ = gallons of gasoline to be condensed per hour.

Heat absorbed in condensing 1 gallon of gasoline to 60° F = 1550 B. T. U.

Heat absorbed in condensing 1 gallon of kerosene to 60°F = 2400 B. T. U.

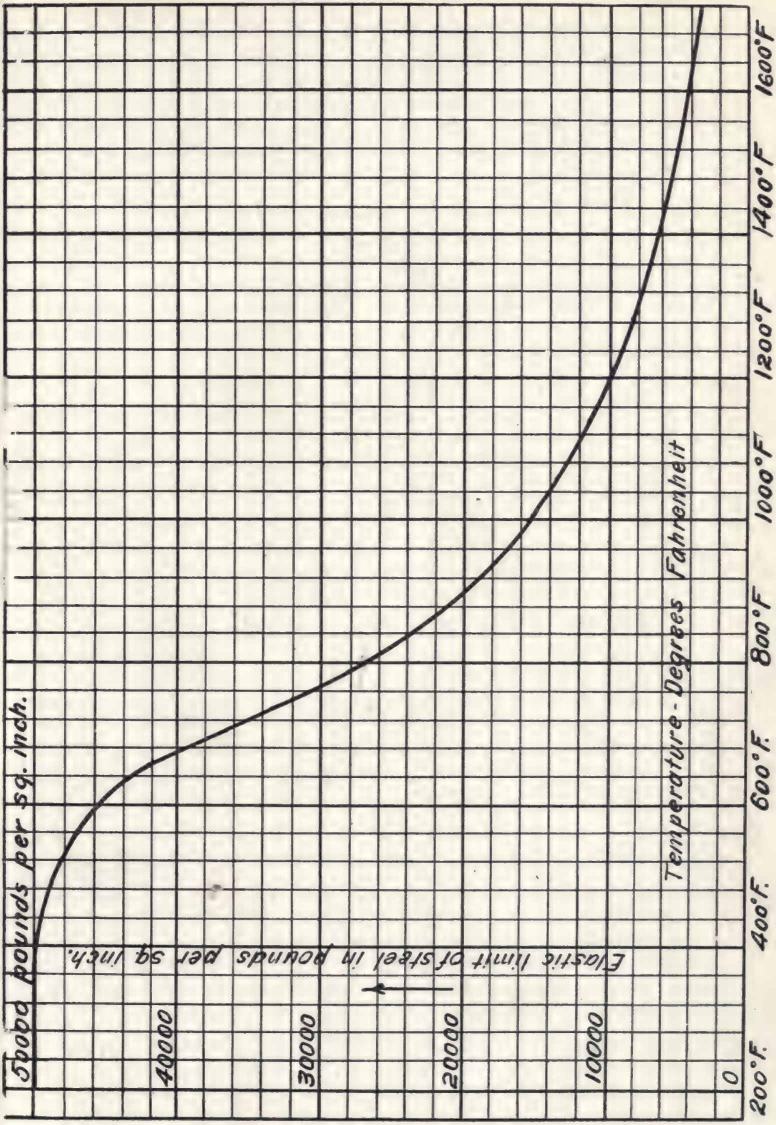
Heat absorbed by oil in distilling off 50% from it as gasoline and kerosene is 2100 B. T. U. per gallon of crude oil.

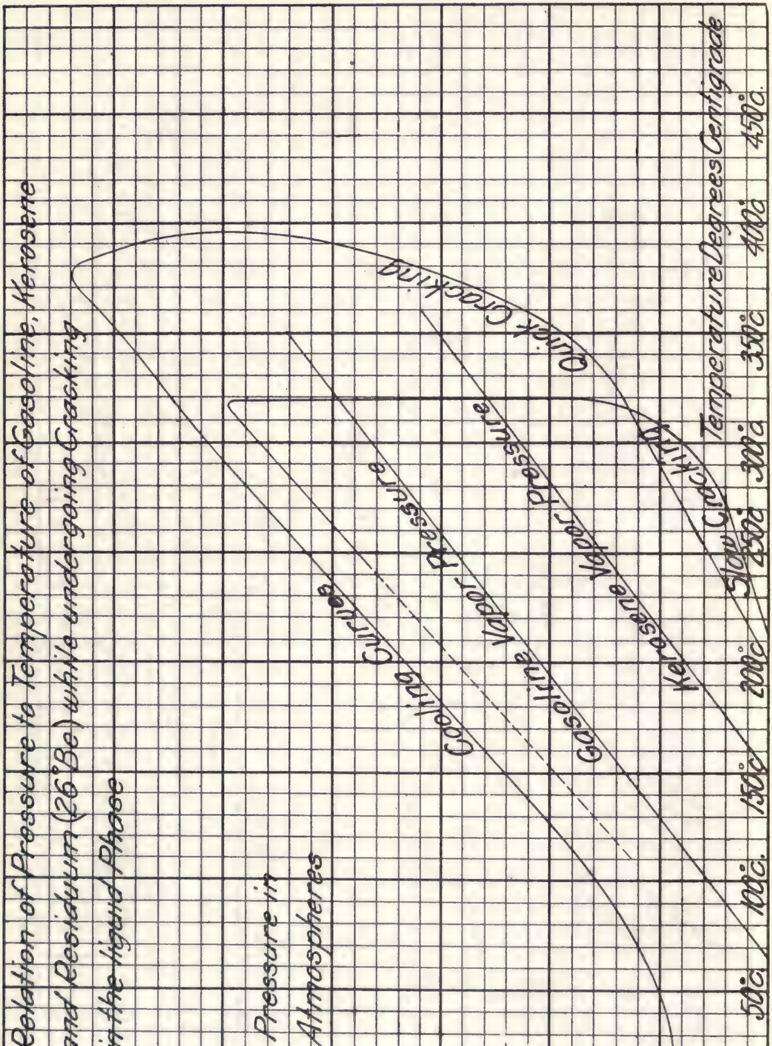
Heat absorbed by oil in distilling to coke is approximately 3000 B. T. U. per gallon.

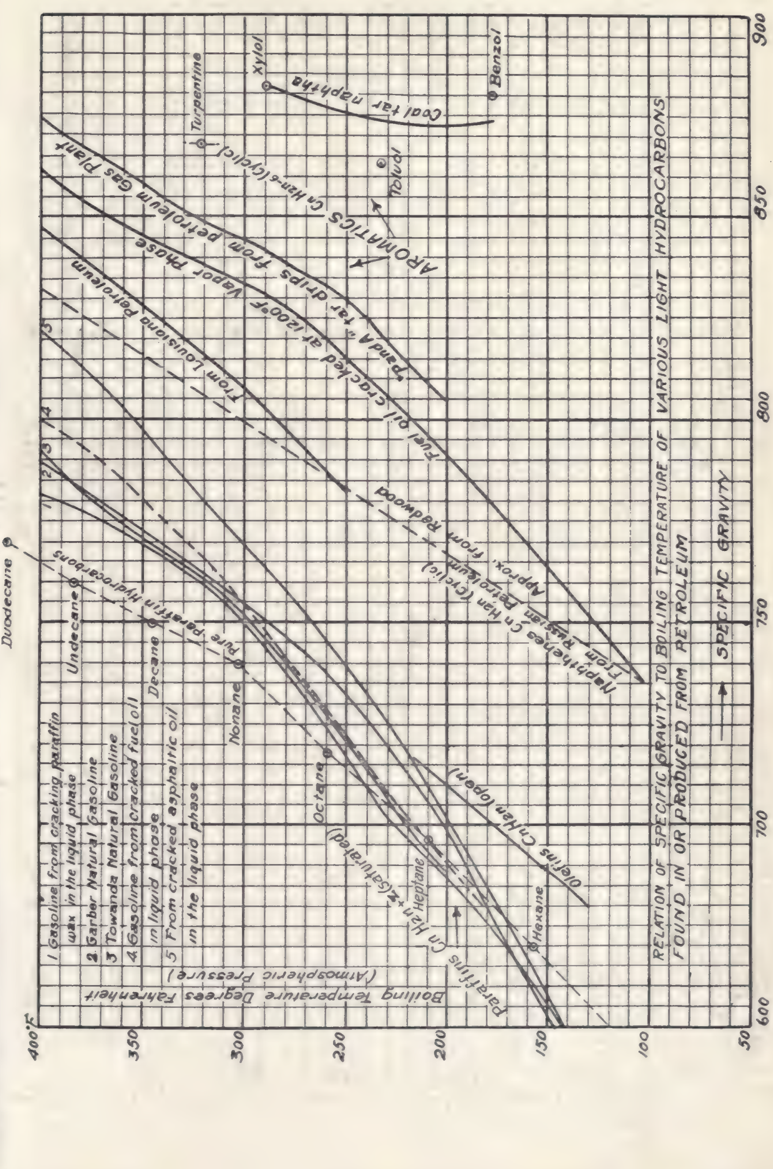
Amount of condenser surface required to properly condense one gallon of gasoline per hour = 2 sq. ft.; 1 gallon of kerosene per hour = 1 sq. ft. This is lessened with cold water and with larger quantities of water and varies with the length and cross section of the condenser tubes.

The cross section of the vapor line should be .05 sq. in. per gallon of gasoline per hour. The cross section of the condenser tubes may be reduced ½ after first ⅓ of length and ¼ more after second ⅓ of length.

The same water used for condensing the benzine or gasoline fraction in crude distillation may be used to condense the kerosene fraction.


50000 pounds per sq. inch.
40000
30000
20000
10000
0
Elastic limit of steel in pounds per sq. inch.
Temperature - Degrees Fahrenheit
200°F.
400°F.
600°F.
800°F
1000°F
1200°F
1400°F
1600°F


Relation of Pressure to Temperature of Gasoline, Kerosene
and Residuum (26° Be) while undergoing Cracking
in the liquid Phase
Pressure in
Atmospheres
0
10
20
30
40
50
60
Quick Cracking
Slow Cracking
Cooling Curves
Cooling Vapor Pressure
Gasoline Vapor Pressure
Kerosene Vapor
50°c.
100°c.
150°c.
200°c.
250°c.
300°c.
350°c.
400°c.
450°c.
Temperature Degrees Centigrade




RELATION OF SPECIFIC GRAVITY TO BOILING TEMPERATURE OF VARIOUS LIGHT HYDROCARBONS FOUND IN OR PRODUCED FROM PETROLEUM

# Equilibrium Cracking Tests on Different Heavy Petroleum Hydrocarbons

| Oil used | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | No. 9 | No. 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Specific Gravity | 0.912 | 0.935 | 0.868 | 0.820 | 0.953 | 0.946 | 0.889 | 0.820 | 0.886 | 0.994 |
| Baume' Gravity | 23.5 | 19.7 | 31.3 | 40.8 | 16.9 | 18.0 | 27.5 | 40.8 | 31.6 | 10.8 |
| Amount cc | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Viscosity at 70°F | 810 | 3360 | 183 | solid | 5400 | 1038 | 272 | 34 | 66 | 14500 |
| Max. Pressure Atm | 59 | 60 | 58 | 58 | 56 | 58.5 | 59.5 | 59.5 | 61 | 50 |
| Max. Temperature °C | 417 | 420 | 420 | 420 | 390 | 412 | 415 | 420 | 414 | 410 |
| Pressure at 400°C Atms | 54 | 55 | 56 | 54.5 | 55 | 54.5 | 54.5 | 53.0 | 55.0 | 45.0 |
| Pressure after Cooling (Atms.) | 10 | 10 | 9.5 | 6.0 | 11.5 | 11.5 | 9.5 | 6.0 | 9.0 | 12.5 |
| Gas % by Weight | 7 | 7 | 6.8 | 4.5 | 8.0 | 8.0 | 6.8 | 5.0 | 6.3 | 8.5 |
| Oil Recovered—cc | 465 | 460 | 495 | 493 | 440 | 442 | 470 | 482 | 470 | 350 |
| Specific Gravity | 0.862 | 0.862 | 0.824 | 0.775 | 0.917 | 0.887 | 0.861 | 0.803 | 0.842 | 0.898 |
| Baume' Gravity | 32.4 | 32.4 | 39.9 | 50.6 | 22.6 | 27.8 | 32.6 | 44.3 | 36.2 | 25.9 |
| Viscosity at 70°F | 47 | 47 | 38 | 38 | 100 | 47 | 42 | 34 | 37 | 110 |
| % Volume | 93.0 | 92.0 | 99.0 | 98.6 | 88.0 | 88.4 | 94.0 | 96.4 | 94.0 | 70.0 |
| % Shrinkage | 7.0 | 8.0 | 1.0 | 1.4 | 12.0 | 11.6 | 6.0 | 3.6 | 6.0 | 30.0 |
| Gasoline (E.P. 410°F) cc | 127 | 139.5 | 147 | 180.7 | 135.5 | 118 | 157 | 199 | 173 | 109 |
| % Volume | 25.4 | 27.9 | 29.4 | 36.1 | 27.1 | 23.6 | 31.4 | 39.8 | 34.6 | 21.8 |
| Specific Gravity | 0.743 | 0.746 | 0.745 | 0.724 | 0.753 | 0.753 | 0.754 | 0.767 | 0.748 | 0.746 |
| Baume' Gravity | 58.4 | 57.6 | 57.9 | 63.3 | 55.9 | 55.9 | 55.6 | 52.5 | 57.1 | 57.6 |
| Residuum % Volume | 67.6 | 64.1 | 69.6 | 62.5 | 60.9 | 64.8 | 68.6 | 56.6 | 59.4 | 48.2 |
| Specific Gravity | 0.926 | 0.926 | 0.886 | 0.820 | 0.962 | 0.944 | 0.911 | 0.845 | 0.925 | 0.982 |
| Baume' Gravity | 21.2 | 21.2 | 28.0 | 40.8 | 15.5 | 18.3 | 23.6 | 35.6 | 21.3 | 12.6 |
| Viscosity at 70°F | 135 | 178 | 70 | 104 | 414 | 218 | 88 | 38 | 86 | 530 |

No. 1 = Mid-Continent fuel oil average of 48 cars on Kansas City market.
No. 2 = Heavy Kansas crude oil from Allen County.
No. 3 = Garber residuum from Enid, Oklahoma.
No. 4 = Paraffin wax.
No. 5 = California crude oil.
No. 6 = California heat treated and skimmed.
No. 7 = Healdton crude.
No. 8 = Mid-Continent kerosene.
No. 9 = Mid-Continent gas oil.
No. 10 = Mexican flux oil (natural).

# Effect of Varying Pressure on the Products of Cracking

## KEROSENE.

Using kerosene of specific gravity 0.8155 in vessel with relation of vapor space to oil of 2 to 1.

| | | | | | |
|---|---|---|---|---|---|
| Pressure, atmospheres | 30 | 40 | 55 | 75 | 90 |
| % distillate to 410°F | 28.0 | 32.5 | 38.0 | 43.7 | 45.9 |
| Shrinkage, volume % | 0.0 | 0.4 | 2.4 | 5.0 | 7.0 |
| Specific gravity of cracked oil | .810 | .808 | .807 | .806 | .805 |
| Specific gravity of residue | .828 | .833 | .845 | .871 | .888 |
| Cold pressure, atmospheres | 2.5 | 4.0 | 6.5 | 10.0 | 11.8 |

## FUEL OIL.

Fuel oil with specific gravity of 0.908 in vessel with relation of vapor space to oil of 2 to 1.

| | | | | | |
|---|---|---|---|---|---|
| Pressure, atmospheres | 30 | 40 | 55 | 75 | 90 |
| % distillate to 410°F | 14.3 | 22.3 | 25.4 | 32.5 | 38.7 |
| Shrinkage, volume % | 3.0 | 3.3 | 9.0 | 12.0 | 14.0 |
| Specific gravity of cracked oil | .879 | .869 | .862 | .837 | .818 |
| Specific gravity of residue | .914 | .918 | .926 | .930 | .932 |
| Cold pressure, atmospheres | 5 | 6 | 10 | 13 | 15.5 |

# Properties of Water White Kerosene Distillate Before and After Cracking

(See page 212.)

| % | Distilling Temperature Before Cracking | Distilling Temperature After Cracking | Gravity of Stream Before Cracking | Gravity of Stream After Cracking |
|---|---|---|---|---|
| 0 | 294°F | Room | .............. | .............. |
| 2.5 | 355 | Room | .............. | .............. |
| 5.0 | 363 | 80°F | .766 = 53.2°Be' | .614 = 98.9°Be' |
| 7.5 | 366 | 105 | .767 = 52.9°Be' | .634 = 91.7°Be' |
| 10.0 | 367 | 130 | .768 = 52.7°Be' | .654 = 84.8°Be' |
| 12.5 | 370 | 158 | .769 = 52.5°Be' | .667 = 80.6°Be' |
| 15.0 | 379 | 188 | .770 = 52.2°Be' | .680 = 76.6°Be' |
| 17.5 | 381 | 218 | .771 = 52.0°Be' | .695 = 72.1°Be' |
| 20.0 | 382 | 237 | .772 = 51.8°Be' | .710 = 67.8°Be' |
| 22.5 | 384 | 256 | .773 = 51.5°Be' | .720 = 65.0°Be' |
| 25.0 | 391 | 269 | .774 = 51.3°Be' | .730 = 63.3°Be' |
| 27.5 | 395 | 282 | .774 = 51.3°Be' | .739 = 59.9°Be' |
| 30.0 | 399 | 296 | .775 = 51.0°Be' | .749 = 57.4°Be' |
| 32.5 | 402 | 310 | .776 = 50.8°Be' | .756 = 55.6°Be' |
| 35.0 | 406 | 319 | .777 = 50.6°Be' | .764 = 53.7°Be' |
| 37.5 | 408 | 328 | .777 = 50.6°Be' | .769 = 52.5°Be' |
| 40.0 | 410 | 340 | .778 = 50.3°Be' | .775 = 51.0°Be' |
| 42.5 | 414 | 352 | .779 = 50.1°Be' | .777 = 50.6°Be' |
| 45.0 | 417 | 359 | .780 = 49.9°Be' | .780 = 49.9°Be' |
| 47.5 | 420 | 366 | .780 = 49.9°Be' | .782 = 49.4°Be' |
| 50.0 | 423 | 371 | .781 = 49.6°Be' | .785 = 48.7°Be' |
| 52.5 | 425 | 376 | .782 = 49.4°Be' | .787 = 48.3°Be' |
| 55.0 | 431 | 386 | .783 = 49.2°Be' | .790 = 47.6°Be' |
| 57.5 | 433 | 396 | .784 = 48.9°Be' | .792 = 47.1°Be' |
| 60.0 | 437 | 405 | .785 = 48.7°Be' | .793 = 46.9°Be' |
| 62.5 | 440 | 414 | .786 = 48.5°Be' | .795 = 46.4°Be' |
| 65.0 | 444 | 418 | .787 = 48.3°Be' | .798 = 45.8°Be' |
| 67.5 | 448 | 422 | .788 = 48.0°Be' | .798 = 45.8°Be' |
| 70.0 | 453 | 429 | .789 = 47.8°Be' | .800 = 45.4°Be' |
| 72.5 | 457 | 436 | .790 = 47.6°Be' | .802 = 44.9°Be' |
| 75.0 | 462 | 443 | .792 = 47.1°Be' | .805 = 44.2°Be' |
| 77.5 | 468 | 450 | .793 = 46.9°Be' | .808 = 43.6°Be' |
| 80.0 | 473 | 459 | .794 = 46.7°Be' | .812 = 42.7°Be' |
| 82.5 | 479 | 468 | .795 = 46.4°Be' | .817 = 41.7°Be' |
| 85.0 | 485 | 484 | .797 = 46.0°Be' | .823 = 40.4°Be' |
| 87.5 | 493 | 500 | .800 = 45.3°Be' | .830 = 38.9°Be' |
| 90.0 | 506 | 523 | .803 = 44.7°Be' | .837 = 37.5°Be' |
| 92.5 | 516 | 547 | .807 = 43.8°Be' | .851 = 34.7°Be' |
| 95.0 | 533 | 600 | .812 = 42.7°Be' | .866 = 31.9°Be' |
| 97.5 | 560 | 648 | .............. | .936 = 19.6°Be' |
| 100.0 | 608 | 700 | .............. | .............. |
| Gravity of sample | | | .7845=48.9°Be' | .766 = 53.2°Be' |

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS

of Benton Process Gasoline; Specific Gravity, 0.758; °Be′ U. S., 54.7 °Be′ Tag, 55.1°; Olefins, 16.0%.

| % | Time | Temp. °F. | Gravity of Fraction. | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|---|
| | 10:09 | | | | |
| 0 | 10:14 | 85 | | | |
| | | 155 | | | |
| 5 | 10:22 | 164 | 0.694=72.4°Be′ | 0.694=72.4°Be′ | 0.694=72.4°Be′ |
| | | 171 | | | |
| 10 | 10:28 | 176 | 0.695=72.1°Be′ | 0.694=72.4°Be′ | 0.689=71.2°Be′ |
| | | 184 | | | |
| 15 | 10:35 | 188 | 0.701=70.3°Be′ | 0.696=71.8°Be′ | 0.705=69.2°Be′ |
| | | 193 | | | |
| 20 | 10:42 | 199 | 0.710=67.8°Be′ | 0.700=70.6°Be′ | 0.714=66.6°Be′ |
| | | 206 | | | |
| 25 | 10:48 | 211 | 0.718=65.5°Be′ | 0.704=69.5°Be′ | 0.722=64.4°Be′ |
| | | 216 | | | |
| 30 | 10:54 | 222 | 0.727=63.1°Be′ | 0.707=68.6°Be′ | 0.731=62.0°Be′ |
| | | 228 | | | |
| 35 | 10:58 | 234 | 0.735=61.0°Be′ | 0.711=67.5°Be′ | 0.738=60°2Be′ |
| | | 238 | | | |
| 40 | 11:03 | 244 | 0.742=59.2°Be′ | 0.715=66.4°Be′ | 0.745=58.4°Be′ |
| | | 248 | | | |
| 45 | 11:09 | 254 | 0.748=57.6°Be′ | 0.719=65.3°Be′ | 0.751=56.9°Be′ |
| | | 258 | | | |
| 50 | 11:14 | 264 | 0.755=55.9°Be′ | 0.722=64.4°Be′ | 0.758=55.1°Be′ |
| | | 270 | | | |
| 55 | 11:19 | 278 | 0.761=54.4°Be′ | 0.729=62.6°Be′ | 0.770=52.2°Be′ |
| | | 283 | | | |
| 60 | 11:25 | 290 | 0.767=52.9°Be′ | 0.729=62.6°Be′ | 0.770=52.2°Be′ |
| | | 297 | | | |
| 65 | 11:29 | 306 | 0.773=51.5°Be′ | 0.732=61.8°Be′ | 0.776=50.8°Be′ |
| | | 312 | | | |
| 70 | 11:34 | 320 | 0.779=50.1°Be′ | 0.736=60.7°Be′ | 0.781=49.6°Be′ |
| | | 328 | | | |
| 75 | 11:41 | 336 | 0.784=48.9°Be′ | 0.739=59.9°Be′ | 0.788=48.0°Be′ |
| | | 348 | | | |
| 80 | 11:46 | 362 | 0.793=46.9°Be′ | 0.742=59.2°Be′ | 0.797=46.0°Be′ |
| | | 371 | | | |
| 85 | 11:53 | 388 | 0.801=45.1°Be′ | 0.746=58.1°Be′ | 0.808=43.6°Be′ |
| | | 406 | | | |
| 90 | 11:59 | 428 | 0.815=42.1°Be′ | 0.749=57.4°Be′ | 0.823=40.4°Be′ |
| | | 460 | | | |
| 95 | 12:05 | 492 | 0.832=38.5°Be′ | 0.754=56.1°Be′ | |

Remarks: 36 cc. residuum; loss, ½ %.

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF COAL TAR BENZOL.

Laboratory Number, 44118; Specific Gravity, 0.880; °Be′ U. S., 29.0°; Cold test, 40°F.

| % | Time | Temp. °F. | Gravity of Fraction. | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|---|
| | 3:25 | | | | |
| 0 | 3:31 | 173 | | | |
| | | 178 | | | |
| 5 | 3:37 | 179 | 0.882=28.9°Be′ | 0.882=28.9°Be′ | 0.881=29.1°Be′ |
| | | 180 | | | |
| 10 | 3:42 | 180 | 0.881=29.1°Be′ | 0.881=29.1°Be′ | 0.882=28.9°Be′ |
| | | 180 | | | |
| 15 | 3:47 | 180 | 0.883=28.7°Be′ | 0.882=28.9°Be′ | 0.882=28.9°Be′ |
| | | 180 | | | |
| 20 | 3:51 | 180 | 0.882=28.9°Be′ | 0.882=28.9°Be′ | 0.882=28.9°Be′ |
| | | 180 | | | |
| 25 | 3:56 | 180 | 0.882=28.9°Be′ | 0.882=28.9°Be′ | 0.882=28.9°Be′ |
| | | 180 | | | |
| 30 | 4:00 | 181 | 0.882=28.9°Be′ | 0.882=28.9°Be′ | 0.882=28.9°Be′ |
| | | 181 | | | |
| 35 | 4:05 | 182 | 0.882=28.9°Be′ | 0.882=28.9°Be′ | 0.881=29.1°Be′ |
| | | 182 | | | |
| 40 | 4:10 | 182 | 0.881=29.1°Be′ | 0.881=29.1°Be′ | 0.881=29.1°Be′ |
| | | 182 | | | |
| 45 | 4:15 | 182 | 0.881=29.1°Be′ | 0.881=29.1°Be′ | 0.881=29.1°Be′ |
| | | 182 | | | |
| 50 | 4:19 | 182 | 0.881=29.1°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 183 | | | |
| 55 | 4:23 | 183 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 183 | | | |
| 60 | 4:28 | 184 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 184 | | | |
| 65 | 4:33 | 184 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 185 | | | |
| 70 | 4:38 | 186 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 186 | | | |
| 75 | 4:43 | 187 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.880=29.3°Be′ |
| | | 188 | | | |
| 80 | 4:48 | 189 | 0.880=29.3°Be′ | 0.881=29.1°Be′ | 0.879=29.4°Be′ |
| | | 190 | | | |
| 85 | 4:53 | 192 | 0.879=29.4°Be′ | 0.880=29.3°Be′ | 0.879=29.4°Be′ |
| | | 196 | | | |
| 90 | 4:57 | 199 | 0.879=29.4°Be′ | 0.880=29.3°Be′ | 0.877=29.8°Be′ |
| | | 205 | | | |
| 95 | 5:01 | 216 | 0.876=30.0°Be′ | 0.880=29.3°Be′ | 0.876=30.0′Be° |
| 100 | 5:10 | 225 | 0.876=30.0°Be′ | 0.880=29.3°Be′ | 0.876=30.0′Be° |

# Information Concerning Oil Shales

The chief occurrences of oil shale in the United States are in Western Colorado—Northeastern Utah—Kentucky—Elko, Nevada—Great Falls, Montana—Parkfield, California—New Brunswick, Canada—Alabama—Tennessee and Virginia. It is estimated that in Colorado there are enough oil shales to produce 20,000 million barrels of oil and 300 million tons of ammonium sulphate.

The shale oil industry started in England in 1694. The oil was used for medicinal purposes, later for varnishes and in 1815 for ammonia.

The chief commercial operations on oil shale are in Scotland and were begun in 1847. These industries were demoralized when Pennsylvania petroleum first appeared on the market, but later recovered partially and are now operated with profit. The amount of oil obtainable from one ton of shale varies from one gallon to 90 gallons. In Scotland it is 23 gallons. In Colorado alone there is said to be enough shale to produce 20,000,000,000 barrels of oil and 300,000,000 tons of ammonium sulphate.

Gasoline made from shale is of inferior quality, containing large amounts of olefins and aromatic compounds and giving a large shrinkage on refining.

Shale oil is especially adapted to the uses to which the heavy products of petroleum are now put, such as fuel oil, paraffin wax, lubricants, gas oil and illuminating oil. It is not likely to be so satisfactory for the production of gasoline as is the cracking of heavy petroleums. The character of the oil recovered and the amount of ammonium sulphate produced from shale depend largely upon the method of distillation.

Oil shale rock is a tough brownish to black shale-like rock. As it naturally exists it contains no oil and oil cannot be extracted from it by solvents or by any of the means used for asphaltic sandstone or limestone. The oil is produced from complex organic matter by decomposing it at high temperatures.

The mineral base of oil shales is of the nature of kaolin and contains potash in water-insoluble form.

Cannel coal is of the same chemical nature as oil shale both as to the bitumen and the mineral matter. The hydrocarbons of oil shale and cannel coal more nearly approach petroleum than coal in their calorific value.

Unlike coal, cannel "coal" has no structure or evidence of the former presence of or origin from vegetable matter. It breaks with a conchoidal fracture and is usually free from mineral sulphides such as pyrites of iron. It commonly occurs on the top of the Mississippian (subcarboniferous) and may lie immediately above deposits of galena or sphalerite (zinc).

# Presumptive Operation of 1000-Ton Shale Oil Plant in Western Colorado

(Based upon 1 ton of shale.)

| **Proceeds.** | 1918 | 1913 |
|---|---|---|
| 54 gallons of oil (405 lbs.) | $ 2.70 | $ 1.00 |
| 34 pounds of ammonium sulphate | 2.46 | 1.09 |
| | $ 5.16 | $ 2.09 |
| **Costs.** | | |
| *Cost of mining | $ 1.35 | $ 0.90 |
| Cost of distilling oil and ammonia | .65 | .50 |
| Cost of acid for ammonia | .55 | .16 |
| *Freight on acid to plant | .12 | .12 |
| Cost of preparation of ammonium sulphate for market | .10 | .06 |
| *Freight on ammonium sulphate to market | .17 | .17 |
| *Freight on oil | 1.00 | 1.00 |
| Overhead expense | .40 | .25 |
| | $ 4.34 | $ 3.16 |

*Depend upon local conditions to a large extent.

## PROFITS IN SHALE INDUSTRY BY COMPANIES IN SCOTLAND IN 1910

| Companies. | Dividends. |
|---|---|
| Broxburn | 17.5% |
| Oakland | 15.0 |
| Pumpherston | 50.0 |
| Tarbrax | 15.0 |
| Youngs | 6.0 |
| Delmeny | 5.0 |

## SHALE OIL PRODUCTS

**Yields from "Oil Shale" from Colorado.**

(100,000 million tons of shale of this quality are said to be available.)

| | | | |
|---|---|---|---|
| Oil | = 405 lbs. | =54 gallons | =20.25% |
| Water | = 83 lbs. | =10 gallons | = 4.08% |
| Gas | =1605 cu. ft. | | = 8.86% |
| Ammonium Sulphate=34 lbs. from nitrogen | | | = 0.90% |
| Carbon (not separable)=101 lbs. | | | = 5.05% |
| Mineral matter=1219.2 lbs. | | | =60.96% |

## COMPOSITION OF MINERAL ASH IN SHALE

| | | |
|---|---|---|
| Loss on ignition | | = 11.05% |
| Silica | ($SiO_2$) | = 37.10% |
| Alumina | ($Al_2O_3$) | = 20.30% |
| Iron Oxide | ($Fe_2O_3$) | = 9.20% |
| Lime | ($CaO$) | = 12.05% |
| Magnesia | ($MgO$) | = 5.10% |
| Sulphur | ($SO_3$) | = 4.80% |
| Alkalies and difference | | = 0.40% |
| | | 100.00% |

## PROPERTIES OF SHALE OIL

Commercial Fractions.

| | | |
|---|---|---|
| Naphtha (410°F) "gasoline" | 10.0% | (46° Baume') |
| Burning oil | 18.2% | |
| Gas and lubricating oil | 61.8% | |
| Scale | 10.0% | |

Fractional Distillation of oil.

| Fraction | Boiling Point | Specific Gravity (25°C) |
|---|---|---|
| 0— 10 | 100°C | 0.794=46.3°Be' |
| 10— 20 | 194 | 0.822=40.3 |
| 20— 30 | 230 | 0.846=35.5 |
| 30— 40 | 255 | 0.867=31.5 |
| 40— 50 | 285 | 0.885=28.2 |
| 50— 60 | 309 | 0.899=25.7 |
| 60— 70 | 328 | 0.912=23.5 |
| 70— 80 | 337 | 0.900=25.5 |
| 80— 90 | 345 | 0.910=23.8 |
| 90—100 | 350 | 0.910=23.8 |

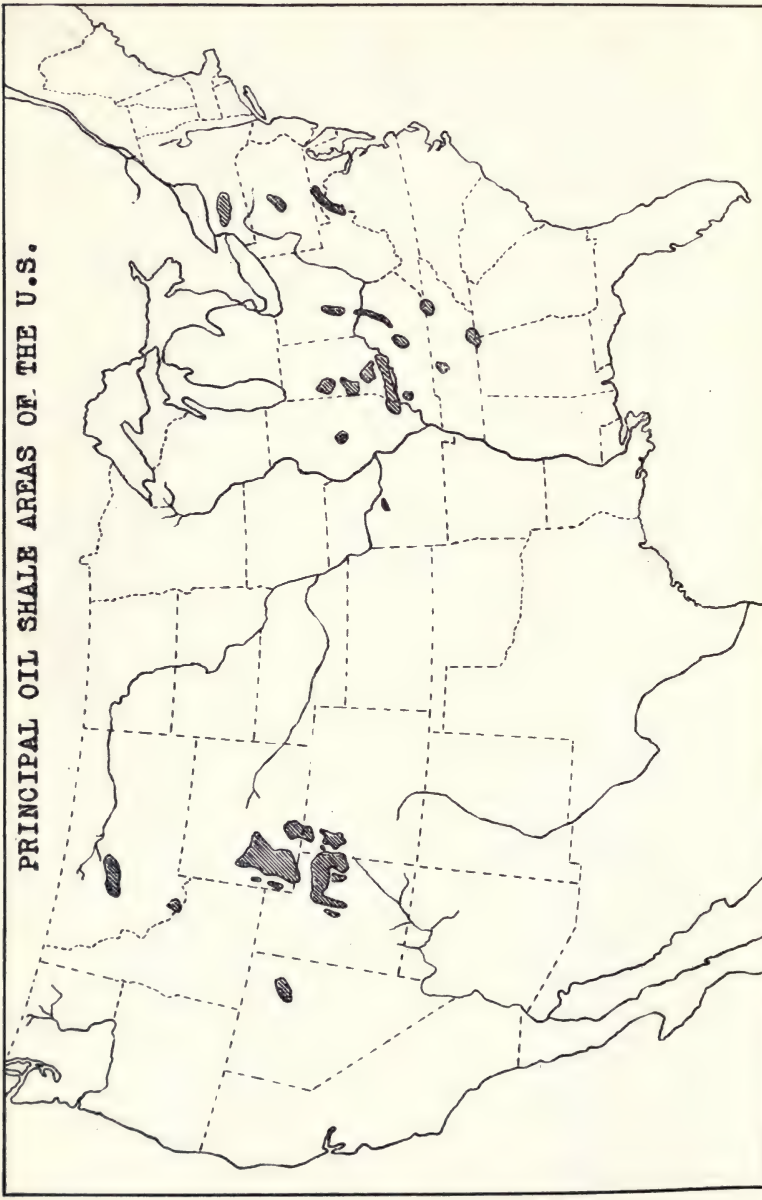
## CANNEL COAL FROM CENTRAL MISSOURI

(Large quantities of this hydrocarbon are found in Missouri.)

| | Sample a | Sample b |
|---|---|---|
| Moisture | 8.14% | 2.56% |
| Volatile hydrocarbons | 41.16 | 44.78 |
| Fixed carbon | 36.63 | 42.72 |
| Ash | 14.07 | 9.94 |
| | 100.00 | 100.00 |
| Fusing of bitumen | none | none |
| Total combustible | 77.79 | 87.50 |
| Heating value in B. T. U., per lb | 12575 | 14095 |
| B. T. U., per lb. of combustible | 16165 | 16110 |
| Sulphur | 2.10% | 1.70% |
| Nitrogen | 1.50 | 1.65 |
| Oil, per ton from retorts | 64 gallons | 72 gallons |
| Ammonium sulphate, per ton | 50 pounds | 55 pounds |
| Coke, per ton | 1080 pounds | 1200 pounds |

## COMPOSITION OF ASH IN CANNEL COAL

| | | | |
|---|---|---|---|
| Silica | ($SiO_2$) | =43.28% | |
| Iron and | ($Fe_2O_3$) | =12.00 | |
| Alumina | ($Al_2O_3$) | =34.16 | 46.16 |
| Lime | ($CaO$) | = 1.49 | |
| Magnesia | ($MgO$) | = 1.01 | |
| Sulphur | ($SO_3$) | = 0.84 | |
| Phosphorus | ($P_2O_5$) | = 0.73 | |
| Potash | ($K_2O$) | = 3.00 | |



PRINCIPAL OIL SHALE AREAS OF THE U.S.

## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF SHALE OIL BEFORE CRACKING.

Laboratory Number 46258, Original Shale Oil.
Specific Gravity, 0.920; °Be' U. S. 22.1°; °Be' Tag 22.3°.
Color, Brownish Black; Sulphur=0.49% B. T. U.%18,425.

| % | Temp. °F. | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| | | | | 0.790=47.6°Be' |
| 5 | 330 | 0.790=47.6°Be' | 0.790=47.6°Be' | 0.802=44.9°Be' |
| | 368 | | | 0.814=42.3°Be' |
| 10 | 378 | 0.814=42.3°Be' | 0.802=44.9°Be' | 0.823=40.4°Be' |
| | 396 | | | 0.833=38.3°Be' |
| 15 | 413 | 0.833=38.3°Be' | 0.812=42.7°Be' | 0.839=37.1°Be' |
| | 426 | | | 0.845=35.9°Be' |
| 20 | 446 | 0.845=35.9°Be' | 0.820=41.0°Be' | 0.853=34.4°Be' |
| | 464 | | | 0.861=32.8°Be' |
| 25 | 479 | 0.861=32.8°Be' | 0.828=39.4°Be' | 0.869=31.3°Be' |
| | 494 | | | 0.876=30.0°Be' |
| 30 | 516 | 0.876=30.0°Be' | 0.836=37.7°Be' | 0.883=28.7°Be' |
| | 530 | | | 0.890=27.5°Be' |
| 35 | 543 | 0.890=27.5°Be' | 0.844=36.1°Be' | 0.895=26.6°Be' |
| | 552 | | | 0.900=25.7°Be' |
| 40 | 576 | 0.900=25.7°Be' | 0.851=34.8°Be' | 0.905=24.8°Be' |
| | 586 | | | 0.909=24.1°Be' |
| 45 | 599 | 0.909=24.2°Be' | 0.857=33.6°Be' | 0.910=24.0°Be' |
| | 604 | | | 0.911=23.8°Be' |
| 50 | 613 | 0.911=23.8°Be' | 0.867=31.7°Be' | 0.916=23.0°Be' |
| | | | | 0.922=21.9°Be' |
| 55 | Gas | 0.922=21.9°Be' | 0.872=30.7°Be' | 0.928=21.0°Be' |
| | | | | 0.934=20.0°Be' |
| 60 | Gas | 0.934=20.0°Be' | 0.877=29 8°Be' | 0.937=19.5°Be' |
| | | | | 0.940=19.1°Be' |
| 65 | Gas | 0.940=19.0°Be' | 0.882=28.9°Be' | 0.943=18.5°Be' |
| | | | | 0.947=17.9°Be' |
| 70 | Gas | 0.947=17.9°Be' | 0.887=28.0°Be' | 0.950=17.4°Be' |

Summary:

| | |
|---|---|
| Water. . .......................... | 2.1% |
| 42.7° Benzine or Naphtha......... | 12.9% |
| 31° Illuminating oil, unrefined..... | 25.0% |
| 24° Gas. Oil or Distillate.......... | 10.0% |
| 18.5° Wax Distillate.............. | 30.0% |
| Residue. . . ....................... | 20.0% |

| | |
|---|---|
| Olefins. . . . ....................... | 58.0% |
| Aromatics. . . ..................... | 27.0% |
| Naphthenes and Paraffins. ...... | 15.0% |

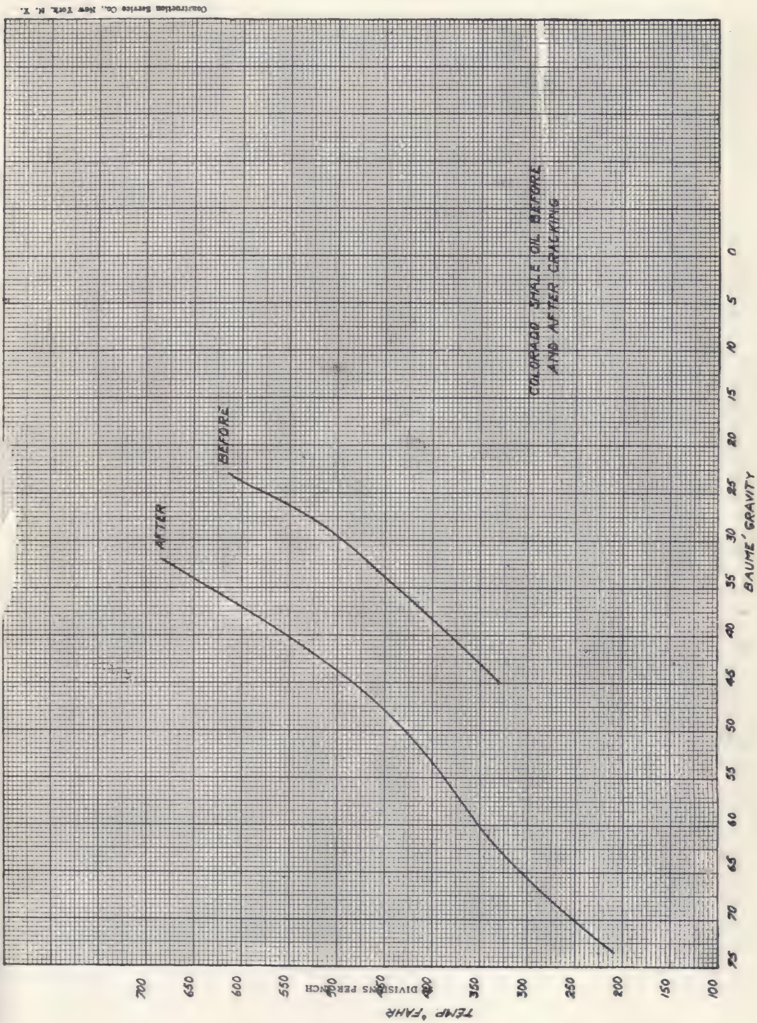
Ammonia in water portion = 0.442% as $NH_3$.

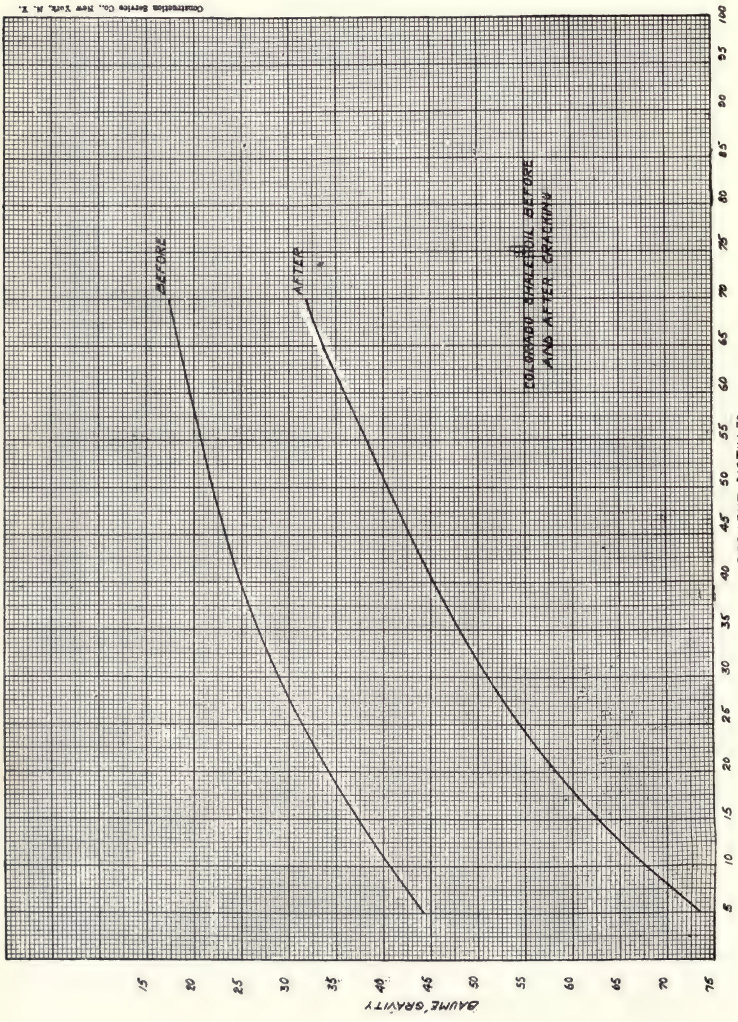
## FRACTIONAL GRAVITY DISTILLATION ANALYSIS OF SHALE OIL RESIDUE.

Laboratory Number 46258, Shale Oil Residue Cracked at 800 lbs. Pressure.
Specific Gravity, 0.896; °Be′ U. S. 26.2; °Be′ Tag 26.4.
Color, Dark Red; Olefins 27.5%.

| % | Temp. °F. | Gravity of Fraction | Gravity of Total Over | Gravity of Stream |
|---|---|---|---|---|
| 0 | 119 | .................... | .................... | .................... |
| | | | | 0.681=76.3°Be′ |
| 5 | 210 | 0.681=76.3°Be′ | 0.681=76.2°Be′ | 0.690=73.6°Be′ |
| | | | | 0.699=70.9°Be′ |
| 10 | 281 | 0.717=65.8°Be′ | 0.699=70.9°Be′ | 0.710=67.8°Be′ |
| | | | | 0.721=64.7°Be′ |
| 15 | 334 | 0.765=53.5°Be′ | 0.721=64.7°Be′ | 0.730=62.3°Be′ |
| | | | | 0.740=59.7°Be′ |
| 20 | 368 | 0.798=45.8°Be′ | 0.740=59.7°Be′ | 0.748=57.7°Be′ |
| | | | | 0.757=55.4°Be′ |
| 25 | 395 | 0.823=40.4°Be′ | 0.757=55.4°Be′ | 0.764=53.7°Be′ |
| | | | | 0.771=52.0°Be′ |
| 30 | 435 | 0.846=35.7°Be′ | 0.771=52.0°Be′ | 0.777=50.6°Be′ |
| | | | | 0.784=49.0°Be′ |
| 35 | 454 | 0.861=32.8°Be′ | 0.784=49.0°Be′ | 0.790=47.6°Be′ |
| | | | | 0.796=46.2°Be′ |
| 40 | 486 | 0.831=29.1°Be′ | 0.796=46.2°Be′ | 0.801=45.1°Be′ |
| | | | | 0.807=43.8°Be′ |
| 45 | 518 | 0.898=26.1°Be′ | 0.807=43.8°Be′ | 0.81[illegible]=42.7°Be′ |
| | | | | 0.818=41.5°Be′ |
| 50 | 543 | 0.911=23.8°Be′ | 0.818=41.5°Be′ | 0.823=40.4°Be′ |
| | | | | 0.828=39.4°Be′ |
| 55 | 582 | 0.930=20.7°Be′ | 0.828=39.4°Be′ | 0.833=38.3°Be′ |
| | | | | 0.838=37.3°Be′ |
| 60 | 623 | 0.945=18.2°Be′ | 0.838=37.3°Be′ | 0.844=36.1°Be′ |
| | | | | 0.855=34.0°Be′ |
| 65 | 651 | 0.959=16.0°Be′ | 0.855=34.0°Be′ | 0.859=33.2°Be′ |
| | | | | 0.862=32.6°Be′ |
| 70 | 679 | 0.965=15.1°Be′ | 0.862=32.6°Be′ | 0.865=32.0°Be′ |

Naphtha in oil charged........... None
Synthetic Oil—
Naphtha. . . .................... 30.0%
Illuminants. . . ................. 25.0%


Construction Service Co., New York, N. Y.
COLORADO SHALE OIL BEFORE AND AFTER CRACKING
BEFORE
AFTER
BAUME' GRAVITY
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
TEMP °FAHR
700 650 600 550 500 450 400 350 300 250 200 150 100
10 DIVISIONS PER INCH


Construction Service Co., New York, N. Y.
BEFORE
AFTER
COLORADO SHALE OIL BEFORE
AND AFTER CRACKING
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
PERCENT DISTILLED
15 20 25 30 35 40 45 50 55 60 65 70 75
BAUME' GRAVITY

# Products of Refining of Light Oil of Gas Works

| | Carbon Disul-phide | Benzene | Toulene | M-zylene | Naph-thalene |
|---|---|---|---|---|---|
| Molecular weight | 76.12 | 78.05 | 92.06 | 106.08 | 128.06 |
| Pounds per United States Gal. (60° F) | 10.57 | 7.36 | 7.27 | 7.26 | 9.60 |
| Specific gravity (0°C/4°C) | 1.2921 | .8999 | .8845 | .8823 | ......... |
| Specific gravity (10°C/4°C) | 1.2773 | .8893 | .8757 | .8738 | ......... |
| Specific gravity (15°C/4°C) | 1.2698 | .8839 | .8714 | .8697 | 1.1517 |
| Specific gravity (20°C/4°C) | 1.2623 | .8786 | .8659 | .8655 | ......... |
| Specific gravity (30°C/4°C) | 1.2473 | .8679 | .8573 | .8574 | ......... |
| Change of Spec. Grav. per 1°C | .00125 | .0012 | .0010 | .00095 | ......... |
| Boiling point at 760 mmHg (°C) | 46.2 | 80.36 | 110.3 | 139.1 | 217.7 |
| Increase in boiling point (°mmHg) | .041 | .043 | .047 | .052 | .059 |
| Vapor pressure mmHg (0°C) | 127.9 | 26.63 | 7.20 | 1.75 | .022 |
| Vapor pressure mmHg (10°C) | 198.5 | 45.68 | 13.02 | 3.45 | .047 |
| Vapor pressure mmHg (15°C) | 244.1 | 58.90 | 17.22 | 4.74 | .062 |
| Vapor pressure mmHg (20°C) | 298.0 | 75.21 | 22.53 | 6.43 | .080 |
| Vapor pressure mmHg (30°C) | 434.6 | 119.34 | 37.46 | 11.43 | .135 |
| Pounds per cu. ft. vapor (60°F=30 in.) | .202 | .209 | .244 | .281 | .339 |
| Kil. per cu. m. vapor (0°C-760mm) | 3.42 | 3.54 | 4.14 | 4.76 | 5.72 |
| Heat combustion (net) 15°C-760mmHg. | | | | | |
| Calories per kil. liquid | .3480 | .9960 | 10.150 | 10.230 | .9700 |
| Calories per liter, liquid | .4420 | .8805 | .8850 | .8910 | 11.170 |
| B. T. U. per pound, liquid | .6260 | 17.930 | 18.270 | 18.410 | 17.460 |
| B. T. U. per U. S. gal., liquid | 66.100 | 132.100 | 132.600 | 133.500 | 167.300 |
| Calories per cu. meter, vapor | 11.550 | 33.600 | 40.150 | 46.500 | 52.400 |
| B. T. U. per cu. ft. vapor | .1300 | .3780 | .4500 | .5210 | .5910 |
| Specific heat (calories per kil.) | 0.240 | 0.419 | 0.440 | 0.383 | 0.314 |
| Heat of vaporiz. (calories per kil.) | 83.8 | 92.9 | 83.55 | 78.25 | ......... |
| Sol. in water (22°C) grm. subs. in 100 gH2O | .219 | .072 | Insol. | Insol. | Insol. |
| Grams H2O in 100g subs | .765 | .241 | Insol. | Insol. | Insol. |
| Melting point (°C) | —108.6 | +5.4 | —92.4 | —54.8 | +80.0 |

# Gas-Manufacturing Processes in Use in the United States

The manufactured gas distributed in the United States is of three principal kinds: Coal gas, carbureted water gas and oil gas.

The manufacture of water gas consists essentially of an intermittent process in which a bed of anthracite coal or coke is brought to a high temperature by an air blast and then steam under pressure is blown through the fuel, forming carbon monoxide, hydrogen and a small amount of carbon dioxide by reaction with the carbon in the fuel. The resultant gas, called blue water gas, has a heating value of approximately 300 B.T.U. per cubic foot and almost no luminosity when burned in an open flame. It is conducted into a fire-brick-lined chamber called the carburetor, which contains staggered rows of fire bricks, called checker brick, heated to incandescence during the blow period. Gas oil or fuel is sprayed into the carburetor while the gas is passing through, forming an oil gas which enriches the blue water gas to any desired heating value or candlepower. Another checker-brick-filled chamber, called the superheater, converts most of the oil-gas vapors into permanent gases, which will not condense again upon cooling. During the formation of the oil gas certain portions of the hydrocarbons which compose the oil are changed in their composition to form benzol, toluol and related hydrocarbons called aromatic compounds. Considerable tar is formed at the same time. This is condensed, scrubbed and washed out of the gas by various means, but usually at a temperature which permits most of the aromatics to go forward with the gas. The sulphur in the gas is removed by iron-oxide purifiers and the gas is metered and leaves the plant at or slightly above atmospheric temperature.

The manufacture of coal gas is essentially different from that of water gas. In this process certain classes of bituminous coals are distilled in fire clay or silica retorts or ovens and the resulting gases are condensed, scrubbed, washed and purified to remove water vapor, tar, ammonia and sulphur. As in the water gas process, certain of the hydrocarbons given off by the coal are transformed by the heat of the retort to aromatic compounds. A small part of these aromatics is washed out of the gas by the wash water and tar, but the larger part remains in the gas. In fact, the cooling of the gas is usually so regulated that most of these substances will remain in the gas to increase its heating value and candlepower. Coal gas retorts take a variety of forms. Among these are coke ovens, chamber ovens, horizontal D-shaped retorts, vertical retorts, inclined retorts, etc. Even those of a given class differ among themselves in details of construction. In most of them the distillation is an intermittent process, but some continuous methods are used. In all these processes the gas produced consists of the same constituents in somewhat different proportions. The form of apparatus used in a given case depends largely upon economic considerations or is governed by certain special qualities which are desired in one or more of the products produced. In all of these coal gas processes coke remains in the retort after distillation. In some of them, as for example in coke ovens, coke is the prin-

cipal product, but in city gas plants gas is the chief product. The operation is carried out in any case to give most satisfactory qualities to the principal product and at the same time obtain as high yields and good quality as possible of the secondary or by-products.

Mixed gas is usually understood to be a mixture of carbureted water gas and coal or coke-oven gas. It is supplied in many cities in the United States where the requirements permit of a mixed gas being supplied. The manufacturing installation for mixed gas is practically two complete installations, one for coal gas and one for carbureted water gas, with their auxiliary scrubbing, condensing, purifying, and metering apparatus entirely independent and separate. The manufactured mixed gas, however, is stored in common holders and delivered through a single distribution system. The coal and water gas thus supplement each other. The uniform but more cumbersome coal-gas production furnishes coke as fuel for the water-gas plant. This in turn takes care of the irregularities of the output, and, where necessary, increases the quality of the gas production, especially where a high candlepower standard is in force.

The oil gas process is at present confined chiefly to the Pacific Coast States, where comparatively cheap oil and expensive coal make the coal and water gas processes less feasible. In oil gas manufacture oil alone is used as fuel for heating the checker bricks of the fixing chambers and oil is sprayed by steam into the chambers where, in contact with the bricks, lampblack and permanent gases are formed. In this process also aromatic compounds are included among the constituents of the gas.

Note.—See Bulletin of Bureau of Standards.

# Average Content of Light Oils in Various Gases

The amount of benzol and toluol formed in any one of these processes is by no means definite. It depends upon the operating conditions and the quality of the raw materials (coal or oil). It would therefore be impossible to predict exactly what the yield of products in a given case would be, but an extensive inquiry into the operation of a number of typical plants has given the following tabulation as the usual range of figures for the various processes. Individual results may vary widely from them in a particular case.

**TABLE 1.—Approximate Yields of Crude Light Oil and Pure Products and Approximate Composition of Crude Light Oil.**

**APPROXIMATE YIELD OF CRUDE LIGHT OIL.**

| | |
|---|---|
| Coal gas. | |
| Horizontal retort. | 3.0-4.0 gallons per short ton coal carbonized |
| Continuous vertical retort | 1.5-2.5 gallons per short ton coal carbonized |
| Inclined retort. | 1.8-2.3 gallons per short ton coal carbonized |
| Coke-oven gas, run of oven | 2.6-3.6 gallons per short ton coal carbonized |
| Carbureted water gas | 8-10 per cent of vol. of gas oil used |
| Oil gas. | 0.2-0.3 gal. per 1000 cu. ft. of gas. |

**APPROXIMATE COMPOSITION OF CRUDE LIGHT OIL.**

| | Benzol Per Cent | Toluol Per Cent | Solvent Naphtha, Wash Oil, Naphthalene, Per Cent |
|---|---|---|---|
| Coal gas: | | | |
| Horizontal retort | 50 | 13-18 | 35 |
| Continuous vertical retort | 30 | 10-15 | 55 |
| Inclined retort | 45 | 13-18 | 40 |
| Coke-oven gas, run of oven | 50 | 14-18 | 35 |
| Carbureted water gas | 40 | 20-25 | 37 |
| Oil gas | 80 | 8-10 | 10 |

**APPROXIMATE YIELD OF PURE PRODUCTS.**

| Gallons per short ton coal carbonized: | Benzol | Toluol |
|---|---|---|
| Coal gas— | | |
| Horizontal retort | 1.5 | 0.4-0.5 |
| Continuous vertical retort | .6 | .2- .3 |
| Inclined retort | .9 | .2- .4 |
| Coke-oven gas, run of oven | 1.5 | .3- .5 |
| Gallons per 1000 cubic feet of gas: | | |
| Carbureted water gas | .15 | .06-.10 |
| Oil gas. | .25 | .02-.03 |

| Paraffins | Specific Gravity | Degrees Boiling Point in Centigrade |
|---|---|---|
| N—heptane | 0.712, at 16°C | 97 |
| Triethylmethane | .689, at 27°C | 96 |
| N—octane | .708, at 12.5°C | 125 |
| Diispbutyl | .714, at 0°C | 108.5 |

# Natural Gas

Natural gas is found trapped in the various strata of the earth, principally in sandstone formations of loose texture, in shale seams and in cavities. It is usually associated with petroleum or coal and occurs in the carboniferous strata or in more recent formations. In coal mines it constitutes what is known as fire damp, being given off from the exposed seams of coal. It is most commonly associated with petroleum in petroleum bearing sand and occupies the space in the sand above the oil. Occasionally it occurs in strata without any oil being present, in which case it is of a slightly different composition than the gas which is found in contact with the oil. In many cases it appears that the gas has been obtained from the atmosphere, the oxygen having been removed by its combination with reducible substances such as sulphides, leaving a residue of nitrogen. This gives to such natural gases the peculiarity of having a very large amount of nitrogen. Associated with the nitrogen there occasionally is found a small amount of Helium which is also an ordinary constituent of air in small quantities. It may be that the difference of solubility of the different gases of the air in water may account for the tendency of accumulation of Helium in such instances. As a rule, however, natural gas consists of hydrocarbons of the same type as petroleum and identical with the hydrocarbons which are given off by the cracking of petroleum.

The proportions in which the different hydrocarbons exist in ordinary gas such as is delivered to Kansas City, Missouri, is something like the following:

| | |
|---|---|
| Methane | 84.7% |
| Ethane | 9.4% |
| Propane | 3.0% |
| Butane | 1.3% |
| Nitrogen | 1.6% |

This gas has the greater portion of the heavy hydrocarbons condensed out on account of the high pressure in the pipe lines. Such a gas is a mixture of methane with a varying amount of the other gases. As shown by the above table, the gases ethane, propane and butane furnish much of the heating value of the gas. A gas with a considerable amount of gasoline vapor in it will have a considerably higher heating value than one from which it has been removed, or known as a dry gas.

The compositions of the natural gas used in eight cities in the United States are as follows:

| City | Methane Per Cent | Ethane Per Cent | Nitrogen Per Cent |
|---|---|---|---|
| Pittsburgh, Pa | 79.2 | 19.6 | 1.2 |
| Louisville, Ky. | 77.8 | 20.4 | 1.8 |
| Buffalo, N. Y. | 79.9 | 15.2 | 4.9 |
| Cincinnati, O. | 89.8 | 19.5 | .7 |
| Cleveland, O | 80.5 | 18.2 | 1.3 |
| Springfield, O. | 80.3 | 14.7 | 5.0 |
| Columbus, O | 80.4 | 18.1 | 1.5 |
| Chelsea, Okla | 75.4 | 17.7 | 6.6 |

These analyses were made by the ordinary combustion method and hence show only the two predominating paraffin hydrocarbons.

The composition of gases found in Kansas and Oklahoma as given by Allen and Lyder are shown by the following table:

| Location | Methane | Ethane | Nitrogen | B.T.U. per Cubic Foot |
|---|---|---|---|---|
| Augusta, Kas. | 10.54 | 1.64 | 87.69 | 129 |
| Cowley County, Kas. | 16.27 | 3.01 | 80.23 | 209 |
| Chautauqua County, Kas. | 42.38 | 1.85 | 55.29 | 441 |
| Chautauqua County, Kas. | 49.01 | 3.89 | 46.67 | 541 |
| Elsworth, Kas. | 61.09 | 1.09 | 37.20 | 609 |
| Ponca City, Okla. | 44.60 | 14.86 | 40.10 | 688 |
| Kay County, Okla. | 57.91 | 9.89 | 31.65 | 735 |
| Chautauqua County, Kas. | 85.53 | 0.15 | 12.95 | 839 |
| Chautauqua County, Kas. | 79.13 | 7.79 | 11.39 | 894 |
| Butler County, Kas. | 62.15 | 18.38 | 18.64 | 930 |
| Montgomery County, Kas. | 83.04 | 8.54 | 7.95 | 970 |
| Blackwell, Okla. | 70.69 | 18.65 | 9.32 | 1025 |
| Cushing, Okla. | 70.74 | 21.64 | 7.49 | 1059 |
| Bartlesville, Okla. | 70.50 | 24.60 | 3.21 | 1125 |

The presence of such a large amount of nitrogen in some cases makes the gas almost valueless unless some process is used whereby the nitrogen may be adapted to chemical processes.

While natural gas has a very high heating value in comparison with water gas, water gas has the advantage in that it gives a more intense flame. The comparison of various commercial gases is shown in the following table:

## PROPERTIES OF NATURAL AND MANUFACTURED GASES.

| Constituents | Avg. Pa. and W. Va. | Avg. Ohio and Ind. | Avg. Kansas | Avg. Coal Gas | Avg. Water Gas | Avg. Producer Gas from Bituminous Coal |
|---|---|---|---|---|---|---|
| Marsh gas, $CH_4$ | 80.85 | 83.60 | 93.65 | 40.00 | 2.00 | 2.05 |
| Other hydrocarbons | 14.00 | .30 | .25 | 4.00 | .00 | .04 |
| Nitrogen | 4.60 | 3.60 | 4.80 | 2.05 | 2.00 | 56.26 |
| Carbonic acid $CO_2$ | .00 | .20 | .30 | .45 | 4.00 | 2.60 |
| Carbonic oxide CO | .40 | .50 | 1.00 | 6.00 | 45.50 | 27.00 |
| Hydrogen | .10 | 1.50 | .00 | 46.00 | 45.00 | 12.00 |
| Hydrogen sulphide | .00 | .15 | .00 | .00 | .00 | .00 |
| Oxygen | trace | .15 | .00 | 1.50 | 1.50 | .05 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Pounds in 1,000 cu. ft. | 47.50 | 48.50 | 49.00 | 33.00 | 45.60 | 75.00 |
| Sp. grav. air being 1.00 | 0.624 | 0.637 | 0.645 | 0.435 | 0.600 | 0.935 |
| B.T.U. per cu. ft. | 1,145 | 1,095 | 1,100 | 755 | 350 | 155 |

(a) 1,000 cu. ft. of air at an atmospheric pressure of 14.7 pounds and at a temperature of 62°F weighs 76.1 pounds and is a mechanical mixture of 23 parts of oxygen and 77 parts of nitrogen by weight.

(b) B.T.U. equals British thermal units, which indicate the heat necessary to raise one pound of pure water at 39°F one degree.

Natural gas may have its origin from a sand which is entirely separated from sand containing oil or it may come from above the oil in the same sand as oil.

In the latter case the lighter portions of the oil will have been volatilized and carried into the gas. Such a gas is known as a "wet" gas. In other words, the wet gas is composed of the usual constituents of dry gas; that is, methane, ethane, propane and butane, and in addition pentane, hexane and heptane. These last three are liquid at ordinary temperatures and are the most desirable components of gasoline.

Gas coming from a sand containing no oil is "dry" gas and does not contain the pentane, hexane and heptane.

A "wet" gas coming from an unknown sand indicates the presence of oil in that sand.

In the ordinary oil well the gas is allowed to escape between the casing of the well and the tube which has been inserted for withdrawal of the oil. The gas so collecting in the casing is known as casinghead gas and may be used or allowed to escape.

This gas collecting in the casinghead of an oil well is "wet" gas and contains some of the gasoline from the oil. The gasoline which may be compressed from it or refrigerated from it is then known as "casinghead" gasoline.

The lighter the oil with which the casinghead gas has been associated, the greater ordinarily will be the amount of gasoline contained in the gas.

Ever since natural gas has been conducted in pipe lines it has been known that gasoline could be separated by pressure and much has been incidentally so produced. More recently the great demand for gasoline has encouraged the design of hundreds of special plants for the extraction of gasoline from natural gas.

In 1904, at Titusville, Pennsylvania, Fasenmeyer made casinghead gasoline by pumping the gas under pressure through a coil under water.

In the early methods pressures of about 50 pounds per square inch were used. Later condensing with a pressure of 400 pounds per square inch was found to produce too "wild" a gasoline or one that escaped too easily on handling. A pressure of 250 pounds per square inch is now used, and the pressure of the condensed liquid is controlled by absorbing it directly into heavier naphtha.

At first the compression was done in one stage, but it is the custom now to do it in two stages. The gravity of the product is from 80 to 100° Baumé.

The amount of casinghead gasoline present in a gas will depend upon the character of the oil associated with it, the temperature, the pressure, the compactness of the sand and the condition in the sand at the point tapped.

The amount of gasoline obtained from casinghead gas in the Mid-Continent field varies from ½ to 8 gallons per 1,000 cubic feet. A typical gas yields 2½ gallons per 1,000 cubic feet. Many yield 3 to 4 gallons per 1,000 cubic feet.

The total production of casinghead gasoline in the United States is shown on page 24.

The cost of plants for producing casinghead gasoline has varied from $12 to $25 per thousand cubic feet of gas handled, and the operation of the plants has been uniformly successful and highly profitable.

While the type of plant ordinarily constructed is for compression methods, it is probable that the absorption method will be more generally adopted. The operation of the absorption method is similar to

that of extracting toluol from coal gas and may be applied to a natural gas capable of yielding 1 pint of gasoline per 1,000 cu. ft. By the use of the absorption process 50 million cu. ft. of natural gas would be available per day and 100 million gallons of light gasoline would be made.

**Yield of Gasoline from Casinghead Natural Gas by Compression Method, Corresponding to Absorption and Specific Gravity Tests.**

| Absorption by Oil, per cent | Specific Gravity (Air=1) | Yield of Gasoline, Gallons per 1,000 Cubic Feet of Gas | Absorption by Oil, per cent | Specific Gravity (Air=1) | Yield of Gasoline, Gallons per 1,000 Cubic Feet of Gas |
|---|---|---|---|---|---|
| 16 | 0.64 | None | 50 | 1.29 | 3.00 |
| 23 | .83 | 1.00 | 48 | 1.37 | 3.50 |
| 30 | .90 | 1.75 | 44 | 1.38 | 3.50 |
| 37 | 1.00 | 2.00 | 65 | 1.38 | 4.00 |
| 39 | 1.03 | 2.50 | 84 | 1.41 | 4.50 |
| 38 | 1.07 | 3.00 | 86 | 1.46 | 5.00 |
| 54 | 1.21 | 3.50 | | | |

One casinghead plant figures its probable yield of gasoline in relation to the gravity (G) of the air free gas as follows:

$$\text{Recovery in gallons per 1,000 cu. ft.} = \frac{2\,(15G - 10)}{3}$$

Two-thirds of this amount is marketed.

**Helium in Natural Gas.**

| Locality | Helium | Nitrogen | Methane | Ethane |
|---|---|---|---|---|
| Dexter, Kansas | 1.84% | 82.70% | 14.85% | 0.41% |
| Eureka, Kansas | 1.50 | 46.40 | 51.40 | 0.00 |
| Fredonia, Kansas | 0.61 | 16.40 | 82.25 | 0.00 |
| Kansas City, Missouri | 0.013 | 3.65 | 87.20 | 7.03 |

By H. P. Cady and D. F. McFarland.—J. A. C. S., Vol. 24, p. 1530, 1907.

The chief helium producing natural gas is in Kansas with smaller amounts in the gas at Petrolia, Texas.

**Properties of Incombustible Gases in Natural Gas.**

| | Helium (He) | Nitrogen (N) |
|---|---|---|
| Combining weight | 1.99 | 14.01 |
| Molecular weight | 3.99 | 28.02 |
| Specific gravity (air = 1) | 0.1368 | 0.96737 |
| Liquefying point | —268.5°C | —195.5°C |
| Freezing point | —269.0°C | —210.5°C |
| Solubility in cold water | 1.487% | 2.348% |
| Absorption by platinum | great | little |
| Weight per cubic foot, pounds (Air = 0.080728) | .01105 | .07831 |

**Extracting Helium From Natural Gas**

The process is essentially one of liquefaction by cold and pressure. All of the constituents in natural gas are liquefied except the helium and then separated from the latter.

When the armistice was signed about 45,000 cubic feet of helium had been extracted and was waiting shipment overseas. Several million dollars had been invested in plant equipment in Texas. The cost of extraction was estimated at 10c per cubic foot.

Natural gas to be valuable as a source of helium should contain at least 0.50 per cent of the gas. It is probable that even this quantity will offer great difficulty in the extraction work, although with experience and cheaper methods which will come with practice even smaller quantities may be valuable. The largest quantity ever discovered in natural gas is something over 2 per cent.

The presence of helium in natural gas was discovered by H. P. Cady and D. F. McFarland of the University of Kansas in 1907. (See Journal of American Chemical Society, Vol. XXIX, p. 1523, November, 1907.)

**Lifting Power of Gases in Balloons.**

| | Pounds per 1,000 Cu. Ft. | Compared with Hydrogen |
|---|---|---|
| Hydrogen | 75.138 lbs. | 100.0 % |
| Helium | 69.748 lbs. | 92.84% |
| Ammonia | 33.188 lbs. | 44.16% |
| Natural gas (methane) | 36.088 lbs. | 48.03% |

# Gas Carbon Black From Natural Gas

About 1,000 cubic feet of natural gas of specific gravity of .86 are required to make one pound of carbon black.

The operation of making carbon black consists of burning the gas without air under a series of sheet iron shields which collect the carbon from the yellow flame.

The type of burner used is the old style lava tip originally used for lighting purposes with artificial gas. Many thousand tips are used at one plant.

The carbon is scraped off the shields and packed for shipment in 12½-pound sacks.

Plants of this character require very little labor and can be run under the supervision of the plant foreman, thus carrying little or no overhead expense.

Carbon black is mainly used in printers' ink and is a necessary article.

Carbon black is far superior for filler in rubber tires.

The market price of carbon black is from 12c to 25c per pound.

One thousand feet of natural gas contains 35 to 40 pounds of carbon. Practically no plants get over 2 pounds of gas carbon from 1,000 feet of gas, an average of about 1 pound. The smallest practical size unit should handle two million feet of gas per day, producing 2,000 to 3,000 pounds of carbon black. Ordinarily such a plant would cost not less than $60,000.

# About Natural Gas and Its Usefulness

An average sample of natural gas has 950 B.T.U. per cubic foot.
1 lb. mill coal will evaporate 9 lbs. water.
1 gal. oil will evaporate 100 lbs. water.
1 cu. ft. gas will evaporate 0.85 water.
1 ton coal used under boilers = 18,500 cu. ft. of gas.
1 bbl. oil (42 gal.) under boilers = 5,000 cu. ft. of gas.
40 to 50 cu. ft. of gas = 1 boiler H.P.

Gas Engines:
Highest grade gas engines develop a brake H.P. on 8,500 B.T.U.
Average engine develops a H.P. on 10,500 B.T.U.
Oil well engine develops a H.P. on 20,000 B.T.U.
In a steam turbine plant of over 500 K.W. capacity 30 cu. ft. gas per K.W. is a fair average.
It requires 40,000 cu. ft. of gas to pump one million gallons of water against 200-foot head.

Brick Plants—Gas Used per Thousand Brick Made:
1,800 cubic feet for power.
1,800 cubic feet for drying.
15,000 cubic feet for kilns.

Ice Plants:
2,000 feet gas per ton of refrigeration.

Zinc Plants:
15,000 cubic feet for roasting per ton of metal produced.
65,000 cubic feet for smelting per ton of metal produced.
20,000 cubic feet for power and miscellaneous uses per ton of metal produced.

Cement Plants:
60 to 100 cubic feet per barrel for power.
80 to 100 cubic feet per barrel for roasters.
1,800 to 2,600 cubic feet per barrel for kilns.

Salt Plants:
Direct-fire pans, 9,000 cubic feet per ton.
Stream pans, 10,000 cubic feet per ton.
Single-effect vacuum pan, 15,000 cubic feet per ton.
Double-effect vacuum pan, 10,000 cubic feet per ton.
Triple-effect vacuum pan, 6,000 cubic feet per ton.

Flour Mills:
200 to 400 cubic feet per barrel.

Gas Compressors:
Horsepower required to compress 1,000 cu. ft. of gas per minute:

| | | |
|---|---|---|
| To 15 lbs. | 50 H.P. | |
| To 30 lbs. | 85 H.P. | |
| To 45 lbs. | 111 H.P. | |
| To 60 lbs. | 134 H.P. | |
| To 80 lbs. | 117 H.P. | (2 stages) |
| To 100 lbs. | 151 H.P. | (2 stages) |
| To 200 lbs. | 212 H.P. | (2 stages) |

Horsepower required to compress 1,000 cu. ft. of gas per hr.

| | |
|---|---|
| To 15 lbs. | 1 H.P. |
| To 30 lbs. | 1.75 H.P. |
| To 45 lbs. | 2.25 H.P. |
| To 60 lbs. | 2.75 H.P. |

The specific heat of average natural gas is 0.60 B.T.U. per pound, or 0.028 B.T.U. per cubic foot at 32°F.

# Properties of Hydrocarbons Found in Natural Gas and Casinghead Gas

| | Methane | Ethane | Propane | Butane | Pentane | Hexane | Heptane | Octane |
|---|---|---|---|---|---|---|---|---|
| Formula | $CH_4$ | $C_2H_6$ | $C_3H_8$ | $C_4H_{10}$ | $C_5H_{12}$ | $C_6H_{14}$ | $C_7H_{16}$ | $C_8H_{18}$ |
| Molecular weight | 16.03 | 30.05 | 44.07 | 58.08 | 72.10 | 86.12 | 100.13 | 114.15 |
| Specific gravity of liquid | ........ | .432= 194° Be′ | .515= 142° Be′ | .585= 109° Be′ | .630= 92.2° Be′ | .670= 78.9° Be′ | .697= 70.9° | .718= 65.0° |
| Specific gravity of gas | 0.555 | 1.049 | 1.526 | 2.008 | 2.496 | 2.982 | 3.467 | 3.952 |
| Boiling point at atmospheric pressure | −165° C =265° F | −93° C =135° F | −45° C =49° F | +1° C =34° F | 36.3° C =97° F | 69° C= 156° F | 98.4° C =200° F | 125.5° C =258° F |
| Pressure to liquify at 60° F lbs. | ........ | 475 | 105 | 35 | 6.5 | 1.8 | 0.5 | 0.15 |
| Vapor pressure 70° F in percent of atmosphere | 100+ | 100+ | 100+ | 100+ | 55 | 10 | 2.7 | 0.7 |
| Gallons per 1000 cu. ft. @ B. P. reduced to 60° F | ........ | 4.13 | 7.17 | 10.72 | 14.35 | 18.22 | 22.05 | 25.86 |
| Weight per 1000 cu. ft. @ B. P. reduced to 60° F, lbs. | 42 | 79.7 | 116 | 152.6 | 189.7 | 226.6 | 263.5 | 300 |
| Shrinkage in volume by 1 gal. liquid removed per 1000 cu. ft. | ........ | ........ | ........ | ........ | 7.0% | 5.5% | 4.5% | 3.9% |
| Max. possible removable gal. per 1000 cu. ft. @ 70° F, gal. | ........ | ........ | ........ | ........ | 7.8 | 1.8 | 0.6 | 0.18 |
| Heating value in B. T. U. per cu. ft. | 1065 | 1861 | 2685 | 3447 | 4250 | 5012 | 5780 | 6542 |
| B. T. U. per lb. | 25360 | 23350 | 23150 | 22590 | 22400 | 22120 | 21935 | 21807 |
| Cu. ft. air to burn 1 cu. ft. gas | 9.57 | 16.72 | 23.92 | 31.10 | 38.28 | 46.46 | 53.6 | 60.8 |
| Carbon per cent | 75.0 | 80.0 | 81.8 | 82.8 | 83.3 | 83.7 | 84.0 | 84.2 |
| Explosive mixture per cent in air, maximum | 14.5 | 5.0 | 3.5 | 3.0 | 2.5 | 2.2 | 1.9 | 1.6 |
| Minimum | 5.6 | 3.0 | 2.1 | 1.6 | 1.3 | ........ | ........ | ........ |

# Gasoline and Natural Gas Explosions

An explosion or a detonation is a chemical reaction which goes on with increasing velocity and is accompanied by a rise of temperature. The lowest temperature at which combustion or explosion of a mixture may take place is called the ignition temperature. This varies greatly with different kinds of gases, being with ordinary hydrocarbon gases, such as natural gas, about 650°C. The vapors of some substances such as carbon bisulphide and hydrogen sulphide are capable of ignition at much lower temperatures, even as low as 100°C. Some gases even inflame spontaneously at room temperature. These are phosphorous dihydride, boron and silicon hydride and cacodyl. Ordinarily, explosive mixtures are ignited by the presence of a flame or spark at any point in the mixture ordinarily greater than .2 of a millimeter in length. In order that the gaseous mixture explodes it is necessary that the heat generated by the local combustion be greater than the heat absorbed by the surrounding gases. This means of course that if the mixture is heated to a high temperature it will be more readily explosive though the pressure will exert very little influence. An excess of either the combustible agent or the oxidizing agent in the mixture will have the same cooling effect that is exerted by any inert gas. The result is that the limits of explosibility of various mixtures of combustible gases and air are dependent upon the heat generated by the combination and by the heat absorbed in raising the temperature of the gases. For ordinary gases the following limits hold as to the range of combustion with combustible mixtures when air is the oxidizing agent:

# Limits of Explosibility of Mixtures of Combustible Gases and Air

| | | |
|---|---|---|
| Gasoline vapor. . . . . . . . . . . | 1.5— 6.0% | by volume of mixture |
| Methane. . . . . . . . . . . . . . . | 5.5—14.5 | by volume of mixture |
| Ethane. . . . . . . . . . . . . . . . | 2.5— 5.0 | by volume of mixture |
| Natural gas. . . . . . . . . . . . . | 5.0—12.0 | by volume of mixture |
| Acetylene. . . . . . . . . . . . . . | 3.0—73.0 | by volume of mixture |
| Artificial Illuminating gas. | 7.0—21.0 | by volume of mixture |
| Hydrogen. . . . . . . . . . . . . . | 5.0—72.0 | by volume of mixture |
| Carbon Monoxide. . . . . . . . | 15.0—73.0 | by volume of mixture |
| Blast furnace gas. . . . . . . . | 36.0—65.0 | by volume of mixture |
| Water gas. . . . . . . . . . . . . . | 9.0—55.0 | by volume of mixture |
| Coal gas. . . . . . . . . . . . . . . | 6.0—29.0 | by volume of mixture |
| Ethene. . . . . . . . . . . . . . . . | 4.0—22.0 | by volume of mixture |

The striking back of a flame in a burner is caused by the presence of an explosive mixture in the burner. While the usual rate of striking back of the flame or the propagation of an explosion is over 6000 feet per second and about seven times the rate of sound in the same medium; this rate exists only when there is no retardation of the explosive wave caused by the cooling effect of the orifice or tube through which it passes.

# Testing of Capacity of Casinghead Gas Wells

To use the orifice well tester the specific gravity of the gas must be taken. This is fully described on page 350.

To test a well, close all openings but one or if the well is shut in at the casinghead, blow off the well before inserting the orifice well tester. Allow the well to blow into the atmosphere for half an hour or until there is no appreciable decrease in the volume of the gas flowing from it. Screw in the orifice well tester, which carries a two-inch thread, and allow the gas to flow into the atmosphere through the proper size of orifice.

Connect a syphon gauge to the nipple on the side of the orifice well tester, using a short piece of common three-eighths-inch rubber hose. The syphon gauge should be filled with water up to the zero mark on the scale. If the well appears to be large use the large-sized orifice. To correctly determine the proper size of orifice it is necessary to read the gauge and note the height of the water in the glass. Read both sides of the scale and add them together. In other words, measure the difference between the two water levels which is the true pressure in inches of water. By referring to tables that accompany each instrument, or as found on pages 263-5 the flow of a well for a twenty-four hour period will be found under the proper gravity and opposite the pressure.

The specific gravity bottle can be used to take the water pressure of the gas flowing through the orifice in place of the syphon gauge. In this case measure the difference between the two levels of the water.

Use as large an orifice as possible so as not to permit the gas to create a back pressure in the well. A back pressure in the well will decrease the flow of the gas.

**NATURAL GAS PRODUCED IN THE UNITED STATES IN 1916.**

| State | Quantity M.cu.ft. | Price, cents per M.cu.ft. | Value |
|---|---|---|---|
| West Virginia | 299,318,907 | 15.90 | 47,603,396 |
| Pennsylvania | 129,925,150 | 18.74 | 24,344,324 |
| Oklahoma | 123,517,358 | 9.70 | 11,983,774 |
| Ohio | 69,888,070 | 22.32 | 15,601,144 |
| Louisiana | 32,080,975 | 8.29 | 2,660,445 |
| Kansas | 31,710,438 | 15.31 | 4,855,389 |
| California | 31,643,266 | 17.19 | 5,440,277 |
| Texas | 15,809,579 | 18.89 | 3,143,871 |
| New York | 8,594,187 | 29.37 | 2,524,115 |
| Illinois | 3,533,701 | 11.22 | 396,357 |
| Arkansas | 2,387,935 | 10.13 | 241,896 |
| Kentucky | 2,106,542 | 35.73 | 752,635 |
| Indiana | 1,715,499 | 29.34 | 503,373 |
| Wyoming and Colorado | 575,044 | 14.97 | 86,077 |
| Montana | 213,315 | 18.21 | 38,855 |
| Dakotas and Alabama | 77,478 | 40.75 | 31,573 |
| Missouri | 69,236 | 25.41 | 17,594 |
| Tennessee | 2,000 | 57.50 | 1,150 |
| Michigan | 1,298 | 73.04 | 948 |
| Iowa | 275 | 100.00 | 275 |
| Totals | 753,170,253 | 15.96 | 120,227,468 |

## SPECIFIC HEAT OF GASES ENCOUNTERED IN NATURAL GAS AND "CRACKED" GAS.

(H. L. Payne, J. A. & Appl. Chem.)

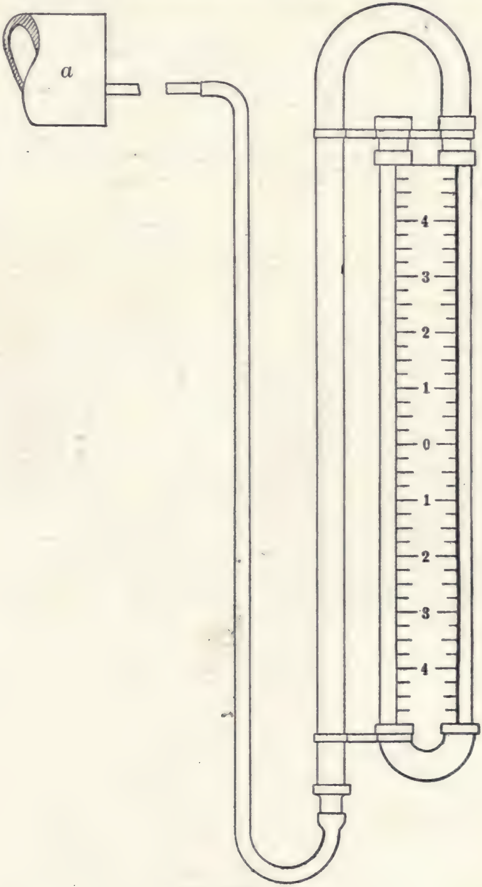
| | B. T. U. per lb. per 1°F | B. T. U per lb. per 1°F |
|---|---|---|
| Air | 0.234 | 0.018 |
| Carbon dioxide | 0.234 | 0.027 |
| Carbonic oxide | 0.245 | 0.019 |
| Hydrogen | 3.41 | 0.019 |
| "Illuminants" | 0.404 | 0.040 |
| Methane | 0.593 | 0.027 |
| Nitrogen | 0.244 | 0.019 |
| Oxygen | 0.217 | 0.019 |
| Aqueous vapor | 0.480 | ..... |

## CALORIFIC VALUE OF NATURAL AND OIL GASES IN BRITISH THERMAL UNITS PER CUBIC FOOT.

| Name | Symbol | 60°F Initial | 32°F Initial 32°F Final | Ignition Point °F |
|---|---|---|---|---|
| Hydrogen | $H_2$ | 326.2 | 345.4 | 1085 |
| Carbonic oxide | $CO$ | 323.5 | 341.2 | 1200 |
| Methane | $CH_4$ | 1009.2 | 1065.0 | 1230 |
| Illuminants | | ...... | 2000.0 | .... |
| Ethane | $C_2H_6$ | 1764.4 | 1861.0 | 1140 |
| Propane | $C_3H_8$ | 2521 | 2657.0 | 1015 |
| Butane | $C_4H_{10}$ | 3274 | 3441.0 | .... |
| Pentane | $C_5H_{12}$ | ...... | 4255.0 | .... |
| Hexane | $C_6H_{14}$ | ...... | 5017.0 | 1400 |
| Ethylene | $C_2H_4$ | 1588 | 1674.0 | 1010 |
| Propylene | $C_3H_6$ | 2347.2 | 2509.0 | 940 |
| Benzene | $C_6H_6$ | 3807.4 | 4012.0 | .... |
| Acetylene | $C_2H_2$ | 1476.7 | 1477.0 | 788 |

# Pitot Tube for Testing Open Flow of Gas Wells

The most accurate way of testing the flow of a gas well is by means of the Pitot tube, which is an instrument for determining the velocity of flowing gas by means of its momentum. The instrument,




Pitot Tube.

as shown in figure usually consists of a small tube, with one end bent at right angles, which is inserted in the flowing gas, just inside

the pipe or tubing *a*, at a point between one-third and one-fourth of the pipe's diameter from the outer edge of the pipe. The plane of the opening in the tube is held at right angles to the flowing gas. At a convenient distance, varying from 1 to 2 feet, an inverted siphon or U-shaped gage, usually half filled with mercury or water, is attached to the other end. If the pressure of the flow is more than 5 pounds per square inch, a pressure gage is required.

In small-sized wells with a flow of not more than 4,000,000 cubic feet per 24 hours, a 12-inch U-gage with water can be used for flows ranging from 4,000,000 to 15,000,000 feet, mercury in a 12-inch U-gage; for 15,000,000 to 35,000,000 feet, a 50-pound spring gage, and for more than 35,000,000 feet, a 100-pound spring gage should be used. The foregoing figures are based on a 6-inch hole.

For convenience, a scale graduated from the center in inches and tenths of an inch is attached between the two limbs of the U-gage. The distance above and below this center line at which the liquid in the gage stands should be added, the object being to determine the exact distance between the high and low side of the fluid in inches and tenths of an inch.

The top joint of the tubing or casing should be free from fittings for a distance of 10 feet below the mouth of the well where the test is made. The test should not be made in a collar or gate or at the mouth of any fitting. The well should be blown off at least three hours prior to making the test.

After the velocity pressure of the gas flowing from the well tubing has been determined in inches of water, inches of mercury, or pounds per square inch, as outlined above, the corresponding flow may be obtained from the following table*. The quantities of gas stated in the table are based on a pressure of 4 ounces above atmospheric, or 14.65 pounds per square inch absolute pressure, a flowin temperature of 60° F., a storage temperature of 60° F., and a speci gravity of 0.60 (air = 1). If the specific gravity is other than 0.60 t flow should be multiplied by $\sqrt{\dfrac{0.60}{\text{specific gravity of gas}}}$.

*Westcott, H. P.: Handbook of Natural Gas, 1915, pp. 176, 177.

**Table for Determining [illegible] Gas Wells by Means of Pitot Tube.**

(Figures show the rate of flow of gas of [illegible] specific gravity from gas well tubing of different sizes in cubic feet per 24 hours for different pressures.)

| Pressure | | | Volume of Gas, in Cubic Feet per 24 Hours, Discharged Through— | | | | Pressure. | Volume of gas, in cubic feet per 24 hours, discharged through— | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inches of Water | Inches of Mercury | Pounds per Square Inch | 1-Inch Tubing | 2-Inch Tubing | 3-Inch Tubing | 4-Inch Tubing | Pounds per square inch. | 1-inch tubing. | 2-inch tubing. | 3-inch tubing. | 4-inch tubing. |
| 0.10 | ........... | ........... | 11,880 | 47,520 | 106,920 | 190,080 | 2.75 | 321,000 | 1,284,000 | 2.889,000 | 5,136,000 |
| .20 | ........... | ........... | 17,130 | 68,544 | 154 224 | 274,176 | 3. | 340,200 | 1,360,800 | 3,061,800 | 5,443,200 |
| .30 | ........... | ........... | 20,568 | 82,272 | 185,112 | 329,088 | 3.25 | 354,120 | 1,416,480 | 3,187,080 | 5,665,920 |
| .40 | ........... | ........... | 23,520 | 94,080 | 211,680 | 376,320 | 3.50 | 367,680 | 1,470,720 | 3,309,120 | 5,882,880 |
| .50 | ........... | ........... | 26,544 | 106,176 | 238,896 | 424,704 | 3.75 | 380,400 | 1,521,600 | 3,423,600 | 6,086,400 |
| .60 | ........... | ........... | 29,112 | 116,448 | 262,008 | 465,792 | 4.00 | 392,880 | 1,571,520 | 3,535,920 | 6,286,080 |
| .7 | ........... | ........... | 31,440 | 125,760 | 282,960 | 503,040 | 4.25 | 405,000 | 1,620,000 | 3,645,000 | 6,480,000 |
| .8 | ........... | ........... | 33,624 | 134,496 | 302,616 | 537,984 | 4.50 | 416,640 | 1,666,560 | 3,749,760 | 6,666,240 |
| .9 | ........... | ........... | 35,640 | 142,560 | 320,760 | 570,240 | 4.75 | 428,280 | 1,713,120 | 3,854,520 | 6,852,480 |
| 1.0 | ........... | ........... | 37,320 | 149.280 | 335,880 | 597,120 | 5.00 | 439,920 | 1,759,680 | 3,959,280 | 7,038,720 |
| 1.25 | ........... | ........... | 41,712 | 166,848 | 375,408 | 667,392 | 6 | 476,040 | 1,904,160 | 4,284,360 | 7,616,640 |
| 1.5 | ........... | ........... | 45,960 | 183,840 | 413,640 | 735,360 | 7 | 517,320 | 2,069,280 | 4,655,880 | 8,277,120 |
| 1.75 | 0.12 | ........... | 49,680 | 198,720 | 447,120 | 794,880 | 8 | 542,400 | 2,169,600 | 4,881,600 | 8,678,400 |
| 2.0 | .147 | ........... | 53,136 | 212.544 | 478,224 | 850,176 | 9 | 569,640 | 2,278,650 | 5,126,760 | 9,114,240 |
| 2.5 | .184 | ........... | 59,400 | 237,600 | 534,600 | 950,400 | 10 | 595,560 | 2,382,240 | 5.360,040 | 9,528,960 |
| 3.0 | .22 | .108 | 65,088 | 260,352 | 585,792 | 1,041,408 | 11 | 621,960 | 2,487,840 | 5,597,640 | 9,951,360 |
| 3.5 | .257 | .126 | 70,272 | 281,088 | 632,448 | 1,124,352 | 12 | 642,600 | 2,570,400 | 5,783,400 | 10,281,600 |
| 4.0 | .294 | .144 | 75,120 | 300,480 | 676,080 | 1,201,920 | 13 | 664,680 | 2,658,720 | 5,982,120 | 10,634,880 |
| 4.5 | .331 | .162 | 79,704 | 318,810 | 717,336 | 1,275,261 | 14 | 683,880 | 2,735,520 | 6,154,920 | 10,942,080 |
| 5.0 | .368 | .18 | 84,000 | 336,000 | 756,000 | 1,344,000 | 15 | 703,080 | 2,812,320 | 6,327,720 | 11,249,280 |
| 6. | .441 | .216 | 92,016 | 368,060 | 828,144 | 1,472,256 | 16 | 721,080 | 2,884,320 | 6,489,720 | 11,537,280 |
| 7. | .515 | .252 | 99,360 | 397,440 | 894,240 | 1,589,760 | 17 | 738,120 | 2,952,480 | 6,643,080 | 11,809,920 |
| 8. | .588 | .288 | 106,272 | 425,088 | 956,448 | 1,700,352 | 18 | 753,960 | 3,015,840 | 6,785,640 | 12,063,360 |
| 9. | .662 | .324 | 112,656 | 450,624 | 1,013,904 | 1,802,496 | 20 | 785,520 | 3,142,080 | 7,069,680 | 12,568,320 |
| 10. | .736 | .36 | 118,800 | 475,200 | 1,069,200 | 1,900,800 | 22 | 803,280 | 3,213,120 | 7,229,520 | 12,852,480 |
| 11. | .8 | .396 | 125,160 | 500,640 | 1,126,440 | 2,002,560 | 25 | 854,880 | 3,419,520 | 7,693,920 | 13 678,080 |
| 12. | .88 | .432 | 130,128 | 520,512 | 1,171,152 | 2,082,048 | 30 | 910,680 | 3,642,720 | 8,196,120 | 14,570,880 |
| ........... | 1.02 | .5 | 138,960 | 555,840 | 1,250,640 | 2,223,360 | 35 | 960,960 | 3,843,840 | 8,648,640 | 15,375,360 |
| ........... | 1.52 | .75 | 170,280 | 681,120 | 1,532,520 | 2,724,480 | 40 | 1,006,680 | 4,026,720 | 9,060,120 | 16,106,880 |
| ........... | 2.03 | 1.00 | 196,680 | 786,720 | 1,770,120 | 3,146,880 | 45 | 1,046,520 | 4,186,080 | 9 418,680 | 16,744,320 |
| ........... | 2.54 | 1.25 | 219,960 | 879,840 | 1,979,640 | 3,519,360 | 50 | 1,081,920 | 4 327,680 | 9,737,280 | 17,310,720 |
| ........... | 3.05 | 1.5 | 240,720 | 962,880 | 2,166,480 | 3,851,520 | 60 | 1,137,120 | 4.548 480 | 10,234,080 | 18,193,920 |
| ........... | 3.56 | 1.75 | 259,920 | 1,039,680 | 2,339,280 | 4,158,720 | 75 | 1,223,400 | 5.217,600 | 11,010 000 | 19,574,400 |
| ........... | 4.07 | 2.00 | 272,640 | 1,090,560 | 2,453,760 | 4,362,240 | 90 | 1,304,400 | 5,217,600 | 11,739,000 | 20,870,400 |
| ........... | 4.57 | 2.25 | 294,600 | 1,178,400 | 2,651,400 | 4,713,600 | 100 | 1,336,920 | 5,347,680 | 12,032,280 | 21,390,720 |
| ........... | 5.08 | 2.50 | 310,800 | 1,243,200 | 2,797,200 | 4,972,800 | | | | | |

For pipe diameters other than those given in the preceding table, the following multipliers should be applied to the figures for 1-inch tubing given in the table.

**Multipliers for Pipe Diameters Ranging from 1½ to 12 inches.**

| Diameter of pipe, inches. | Multiplier. | Diameter of pipe, inches. | Multiplier. | Diameter of pipe, inches. | Multiplier. |
|---|---|---|---|---|---|
| 1½ | 2.25 | 5 | 25 | 8 | 64 |
| 2½ | 6.25 | 5⅝ | 31.64 | 8¼ | 68 |
| 4¼ | 18 | 6 | 36 | 9 | 81 |
| 4⅝ | 21.39 | 6¼ | 39 | 10 | 100 |
| | | 6⅝ | 43.9 | 12 | 144 |

# Flow of Gas in Pipes—Low Pressure

The following formulae are intended for low pressure distribution of gas, with comparatively small differences between the initial and final pressures:

Pole's Formula $$Q = 1350 \sqrt{\frac{d^5h}{sl}}$$

Molesworth's Formula $$Q = 1000 \sqrt{\frac{d^5h}{sl}}$$

Gill's Formula $$Q = 1291 \sqrt{\frac{d^5h}{s\,(l + d)}}$$

Where $Q$ = quantity of gas discharged in cubic feet per hour.
$d$ = inside diameter of pipe in inches.
$h$ = pressure in inches of water.
$s$ = specific gravity of gas, air being 1.
$l$ = length of main in yards.

Oliphant's Formula. A formula determined by F. H. Oliphant for the discharge of gas when the specific gravity is 0.60 is

$$Q = 42a \sqrt{\frac{P_1^2 - P_2^2}{L}}$$

Where $Q$ = discharge in cubic feet per hour at atmospheric pressure.
$P_1$ = initial pressure in pounds per square inch (absolute).
$P_2$ = final pressure in pounds per square inch (absolute).
$L$ = length of main in miles.
$a$ = coefficient (see table below).

For gas of any other specific gravity, s, multiply the discharge by $\sqrt{\frac{0.60}{s}}$, for temperature of flowing gas when observed above 60°F deduct 1 per cent for each 5° and add a like amount for temperatures less than 60°F.

According to Oliphant, the discharge is not strictly proportional to $\sqrt{d^5}$. Using a coefficient of unity for 1-inch pipe he gives

$$a = \sqrt{d^5} + \frac{d^3}{30}$$

**Values of Coefficient "a"**

| Inside diameter inches | a | Inside diameter inches | a | Inside diameter inches | a |
|---|---|---|---|---|---|
| ¼ | .0317 | 3 | 16.5 | 12 | 556 |
| ½ | .1810 | 4 | 34.1 | 16 | 1160 |
| ¾ | .5012 | 5 | 60 | 18 | 1570 |
| 1 | 1.00 | 5⅝ | 81 | 20 | 2055 |
| 1½ | 2.93 | 6 | 95 | 24 | 3285 |
| 2 | 5.92 | 8 | 198 | 30 | 5830 |
| 2½ | 10.37 | 10 | 350 | 36 | 9330 |

For 15 inch outside diameter pipe, 14½ inches inside dia. **a** = 863
For 16 inch outside diameter pipe, 15¼ inches inside dia. **a** = 1025
For 18 inch outside diameter pipe, 17¼ inches inside dia. **a** = 1410
For 20 inch outside diameter pipe, 19¼ inches inside dia. **a** = 1860

# Capacity of Pipe Lines

(Metric Metal Works.)

**Tables to Find the Cubic Feet, per Day of 24 Hours, of Gas of .6 Specific Gravity at Certain Pressure in Pipe Lines of Various Diameter and Lengths.**

Select in table A the number opposite the gauge pressures, in pounds, then from table B select the number opposite the length of line in miles. Multiply these two numbers together and result is the cubic feet that a 1-inch line will discharge for the pressures and length named in twenty-four hours. If the diameter of the pipe is other than one inch, select the number in table C which corresponds with the diameter and multiply this number by the discharge for one inch already secured. The result is the quantity in cubic feet in twenty-four hours discharged by a line whose diameter was selected.

If there are other pressures and lengths not given in the table they can be secured by interpolation. Example—Suppose it is required to find the discharge per day of twenty-four hours of a pipe line having an intake of 200-pound gauge pressure and 25 pounds at the discharge end, the length being 20 miles, and the diameter 8 inches. In table A we find opposite 200 and 25 the number 211.25, and in table B opposite 20 miles, 22.5, multiplying these two numbers the result being 47,637 cubic feet that under the above condition of pressure and length a 1-inch pipe would convey, but the required diameter is 8 inches. Under this number in table C it will be found that 198 corresponds; therefore 47,637 × 198 = 9,433,126, which is the cubic feet discharged in 24 hours.

If the pressure were twenty pounds instead of twenty-five at the discharge end it would be found very closely by adding the figures opposite 15 and 25 and dividing by 2, the result would be 9,469,154.

## TABLE A.

| Intake, Lbs. | Discharge, Lbs. | Resultant | Intake, Lbs. | Discharge, Lbs. | Resultant | Intake, Lbs. | Discharge, Lbs. | Resultant |
|---|---|---|---|---|---|---|---|---|
| 1 | ¼ | 4.7 | 40 | 5 | 51.2 | 110 | 75 | 86.8 |
| 1 | ½ | 3.9 | 40 | 10 | 49.0 | 110 | 85 | 75.0 |
| 2 | ½ | 6.9 | 40 | 15 | 46.1 | 110 | 100 | 49.0 |
| 2 | 1 | 4.7 | 40 | 20 | 42.4 | 125 | 5 | 138.6 |
| 2 | 1½ | 4.0 | 40 | 25 | 37.8 | 125 | 15 | 136.8 |
| 3 | 1 | 8.1 | 40 | 30 | 31.6 | 125 | 25 | 134.2 |
| 3 | 2 | 5.8 | 40 | 35 | 22.9 | 125 | 35 | 130.8 |
| 4 | 1 | 10.1 | 50 | 5 | 61.8 | 125 | 50 | 124.0 |
| 4 | 2 | 8.4 | 50 | 10 | 60.0 | 125 | 75 | 107.2 |
| 4 | 3 | 6.0 | 50 | 15 | 57.7 | 125 | 100 | 79.8 |
| 5 | 1 | 11.8 | 50 | 20 | 54.8 | 125 | 110 | 63.1 |
| 5 | 2 | 10.4 | 50 | 25 | 51.2 | 135 | 5 | 148.7 |
| 5 | 3 | 8.6 | 50 | 30 | 46.9 | 135 | 15 | 147.0 |
| 5 | 4 | 6.2 | 50 | 35 | 41.5 | 135 | 25 | 144.6 |
| 6 | 1 | 13.4 | 50 | 40 | 34.6 | 135 | 35 | 141.4 |
| 6 | 3 | 10.6 | 50 | 45 | 25.0 | 135 | 50 | 135.2 |
| 6 | 5 | 6.3 | 60 | 5 | 72.3 | 135 | 75 | 120.0 |
| 7 | 1 | 14.9 | 60 | 10 | 70.7 | 135 | 100 | 96.3 |
| 7 | 3 | 12.5 | 60 | 15 | 68.8 | 150 | 5 | 163.8 |
| 7 | 5 | 9.0 | 60 | 20 | 66.3 | 150 | 15 | 162.3 |
| 7 | 6 | 6.5 | 60 | 25 | 63.4 | 150 | 25 | 160.1 |
| 8 | 1 | 16.3 | 60 | 30 | 60.0 | 150 | 40 | 155.6 |
| 8 | 3 | 14.1 | 60 | 40 | 51.0 | 150 | 50 | 151.7 |
| 8 | 5 | 11.2 | 60 | 50 | 37.4 | 150 | 75 | 138.3 |
| 8 | 7 | 6.6 | 60 | 55 | 26.9 | 150 | 100 | 118.3 |
| 9 | 1 | 17.6 | 70 | 5 | 82.6 | 150 | 120 | 94.9 |
| 9 | 3 | 15.6 | 70 | 10 | 81.2 | 175 | 5 | 188.9 |
| 9 | 5 | 13.1 | 70 | 20 | 77.5 | 175 | 15 | 187.6 |
| 9 | 8 | 6.8 | 70 | 30 | 72.1 | 175 | 25 | 185.7 |
| 10 | 1 | 19.2 | 70 | 40 | 64.8 | 175 | 35 | 183.3 |
| 10 | 2 | 18.3 | 70 | 50 | 54.7 | 175 | 50 | 178.5 |
| 10 | 4 | 16.3 | 70 | 60 | 40.0 | 175 | 75 | 167.3 |
| 10 | 6 | 13.6 | 80 | 5 | 92.8 | 175 | 100 | 151.2 |
| 10 | 8 | 9.8 | 80 | 10 | 91.6 | 175 | 150 | 94.2 |
| 10 | 9 | 7.0 | 80 | 20 | 88.3 | 200 | 5 | 214.1 |
| 12 | 1 | 21.8 | 80 | 30 | 83.7 | 200 | 15 | 212.9 |
| 12 | 3 | 20.1 | 80 | 40 | 77.5 | 200 | 25 | 211.3 |
| 12 | 6 | 17.0 | 80 | 50 | 69.2 | 200 | 35 | 209.1 |
| 12 | 8 | 14.1 | 80 | 60 | 58.3 | 200 | 50 | 204.9 |
| 12 | 10 | 10.2 | 80 | 70 | 42.4 | 200 | 75 | 195.3 |
| 15 | 1 | 25.4 | 90 | 5 | 103.1 | 200 | 100 | 181.7 |
| 15 | 3 | 24.0 | 90 | 10 | 102.0 | 200 | 125 | 163.2 |
| 15 | 6 | 21.4 | 90 | 20 | 99.0 | 200 | 150 | 137.9 |
| 15 | 9 | 18.0 | 90 | 30 | 94.9 | 200 | 175 | 100.6 |
| 15 | 12 | 13.1 | 90 | 40 | 89.4 | 200 | 190 | 64.8 |
| 20 | 1 | 31.1 | 90 | 50 | 82.5 | 220 | 5 | 234.2 |
| 20 | 4 | 29.4 | 90 | 60 | 73.5 | 220 | 15 | 233.1 |
| 20 | 8 | 26.4 | 90 | 70 | 61.6 | 220 | 25 | 231.6 |
| 20 | 10 | 24.5 | 90 | 80 | 44.7 | 220 | 35 | 229.6 |
| 20 | 15 | 18.0 | 100 | 5 | 113.3 | 220 | 50 | 225.8 |
| 20 | 18 | 11.7 | 100 | 10 | 112.3 | 220 | 75 | 217.1 |
| 25 | 1 | 36.7 | 100 | 15 | 111.0 | 220 | 100 | 204.9 |
| 25 | 3 | 35.7 | 100 | 20 | 109.5 | 220 | 125 | 188.8 |
| 25 | 6 | 34.0 | 100 | 25 | 107.8 | 220 | 150 | 167.3 |
| 25 | 10 | 31.2 | 100 | 35 | 103.6 | 220 | 175 | 138.3 |
| 25 | 15 | 26.5 | 100 | 50 | 94.9 | 220 | 200 | 94.9 |
| 25 | 18 | 22.6 | 100 | 75 | 71.6 | 230 | 5 | 244.1 |
| 30 | 1 | 42.1 | 100 | 85 | 56.8 | 230 | 15 | 243.2 |
| 30 | 3 | 41.2 | 100 | 95 | 33.5 | 230 | 25 | 241.7 |
| 30 | 6 | 39.8 | 110 | 5 | 123.4 | 230 | 35 | 239.8 |
| 30 | 10 | 37.4 | 110 | 15 | 121.4 | 230 | 50 | 236.2 |
| 30 | 15 | 33.5 | 110 | 25 | 118.4 | 230 | 75 | 227.9 |
| 30 | 20 | 28.3 | 110 | 35 | 114.6 | 230 | 100 | 216.3 |
| 30 | 25 | 20.0 | 110 | 50 | 106.8 | 230 | 150 | 181.5 |

## TABLE A—Continued.

| Intake, Lbs. | Dis-charge, Lbs. | Re-sultant | Intake, Lbs. | Dis-charge, Lbs. | Re-sultant | Intake, Lbs. | Dis-charge, Lbs. | Re-sultant |
|---|---|---|---|---|---|---|---|---|
| 230 | 200 | 117.5 | 325 | 250 | 213.0 | 400 | 225 | 338.6 |
| 230 | 215 | 84.4 | 325 | 275 | 177.5 | 400 | 250 | 319.4 |
| 250 | 5 | 264.2 | 325 | 285 | 160.0 | 400 | 275 | 296.9 |
| 250 | 15 | 263.3 | 325 | 300 | 128.0 | 400 | 300 | 270.2 |
| 250 | 25 | 262.0 | 350 | 5 | 364.5 | 400 | 325 | 238.0 |
| 250 | 35 | 260.2 | 350 | 15 | 363.8 | 400 | 350 | 197.5 |
| 250 | 50 | 256.9 | 350 | 25 | 362.8 | 400 | 375 | 141.9 |
| 250 | 75 | 249.3 | 350 | 35 | 361.6 | 425 | 5 | 439.6 |
| 250 | 100 | 238.8 | 350 | 50 | 359.2 | 425 | 15 | 439.0 |
| 250 | 125 | 225.0 | 350 | 75 | 353.7 | 425 | 25 | 438.2 |
| 250 | 150 | 207.4 | 350 | 100 | 346.4 | 425 | 35 | 437.2 |
| 250 | 175 | 184.7 | 350 | 125 | 337.1 | 425 | 50 | 435.2 |
| 250 | 200 | 154.9 | 350 | 150 | 325.6 | 425 | 75 | 430.7 |
| 250 | 230 | 101.0 | 350 | 175 | 311.7 | 425 | 100 | 424.7 |
| 275 | 5 | 289.3 | 350 | 200 | 295.0 | 425 | 125 | 417.1 |
| 275 | 15 | 288.4 | 350 | 225 | 275.0 | 425 | 150 | 407.9 |
| 275 | 25 | 287.2 | 350 | 250 | 251.0 | 425 | 175 | 396.9 |
| 275 | 35 | 285.7 | 350 | 275 | 221.6 | 425 | 200 | 383.9 |
| 275 | 50 | 282.6 | 350 | 300 | 184.4 | 425 | 225 | 368.8 |
| 275 | 75 | 275.7 | 350 | 325 | 132.8 | 425 | 250 | 351.3 |
| 275 | 100 | 266.2 | 375 | 5 | 389.5 | 425 | 275 | 330.9 |
| 275 | 150 | 238.5 | 375 | 15 | 388.8 | 425 | 300 | 307.2 |
| 275 | 200 | 194.6 | 375 | 25 | 387.9 | 425 | 325 | 279.3 |
| 275 | 250 | 117.8 | 375 | 35 | 386.8 | 425 | 350 | 245.7 |
| 300 | 5 | 314.4 | 375 | 50 | 384.6 | 425 | 375 | 203.7 |
| 300 | 15 | 313.6 | 375 | 75 | 379.5 | 425 | 400 | 146.2 |
| 300 | 25 | 312.5 | 375 | 100 | 372.7 | 450 | 5 | 464.6 |
| 300 | 35 | 311.0 | 375 | 125 | 364.0 | 450 | 15 | 464.0 |
| 300 | 50 | 308.2 | 375 | 150 | 353.4 | 450 | 25 | 463.3 |
| 300 | 75 | 301.9 | 375 | 175 | 340.6 | 450 | 35 | 462.3 |
| 300 | 100 | 293.8 | 375 | 200 | 325.4 | 450 | 50 | 460.4 |
| 300 | 125 | 282.2 | 375 | 225 | 307.4 | 450 | 75 | 456.2 |
| 300 | 150 | 268.3 | 375 | 250 | 286.1 | 450 | 100 | 450.5 |
| 300 | 175 | 251.3 | 375 | 275 | 260.8 | 450 | 125 | 443.4 |
| 300 | 200 | 230.2 | 375 | 300 | 230.0 | 450 | 150 | 434.7 |
| 300 | 250 | 170.3 | 375 | 325 | 191.1 | 450 | 175 | 424.4 |
| 300 | 275 | 123.0 | 375 | 350 | 137.4 | 450 | 200 | 412.3 |
| 325 | 5 | 339.4 | 400 | 5 | 414.5 | 450 | 225 | 398.3 |
| 325 | 15 | 338.7 | 400 | 15 | 413.9 | 450 | 250 | 382.1 |
| 325 | 25 | 337.6 | 400 | 25 | 413.1 | 450 | 275 | 363.5 |
| 325 | 35 | 336.3 | 400 | 35 | 412.0 | 450 | 300 | 342.1 |
| 325 | 50 | 333.7 | 400 | 50 | 409.9 | 450 | 325 | 317.2 |
| 325 | 75 | 327.9 | 400 | 75 | 405.1 | 450 | 350 | 288.1 |
| 325 | 100 | 320.0 | 400 | 100 | 398.8 | 450 | 375 | 253.2 |
| 325 | 125 | 309.8 | 400 | 125 | 390.2 | 450 | 400 | 209.8 |
| 325 | 150 | 297.3 | 400 | 150 | 380.8 | 450 | 425 | 150.4 |
| 325 | 175 | 281.9 | 400 | 175 | 369.0 | 475 | 50 | 485.7 |
| 325 | 200 | 263.4 | 400 | 200 | 355.0 | 500 | 50 | 510.0 |

## TABLE B.

| Miles | Multipliers | Miles | Multipliers | Miles | Multipliers |
|---|---|---|---|---|---|
| ⅛ | 2880. | 19 | 231.2 | 61 | 129.1 |
| ¼ | 2016. | 20 | 225.5 | 62 | 128.1 |
| ⅜ | 1652.4 | 21 | 220.1 | 63 | 126.9 |
| ½ | 1419.7 | 22 | 214.9 | 64 | 126.0 |
| ⅝ | 1275.9 | 23 | 210.0 | 65 | 125.1 |
| ¾ | 1158.6 | 24 | 205.7 | 66 | 124.1 |
| ⅞ | 1083.7 | 25 | 201.6 | 67 | 123.1 |
| 1 | 1008.0 | 26 | 197.6 | 68 | 122.2 |
| 1½ | 826.2 | 27 | 193.8 | 69 | 121.3 |
| 1¾ | 763.6 | 28 | 190.5 | 70 | 120.4 |
| 2 | 714.9 | 29 | 187.0 | 72 | 118.7 |
| 2½ | 638.0 | 30 | 183.9 | 74 | 117.2 |
| 2¾ | 607.2 | 31 | 181.0 | 76 | 115.6 |
| 3 | 582.7 | 32 | 178.0 | 78 | 114.2 |
| 3½ | 539.0 | 33 | 175.6 | 80 | 112.7 |
| 4 | 504.0 | 34 | 172.9 | 82 | 111.2 |
| 4½ | 475.5 | 35 | 170.3 | 84 | 109.9 |
| 5 | 450.0 | 36 | 168.0 | 86 | 108.7 |
| 5½ | 428.9 | 37 | 165.8 | 88 | 107.5 |
| 6 | 411.4 | 38 | 163.6 | 90 | 106.2 |
| 6½ | 395.3 | 39 | 161.3 | 92 | 105.1 |
| 7 | 380.4 | 40 | 159.5 | 94 | 103.9 |
| 7½ | 367.9 | 41 | 157.5 | 96 | 102.9 |
| 8 | 356.2 | 42 | 155.6 | 98 | 101.8 |
| 8½ | 345.2 | 43 | 153.7 | 100 | 100.8 |
| 9 | 336.0 | 44 | 152.0 | 102 | 99.8 |
| 9½ | 327.3 | 45 | 150.2 | 105 | 98.3 |
| 10 | 319.0 | 46 | 148.7 | 107 | 97.5 |
| 10½ | 311.1 | 47 | 146.9 | 110 | 96.0 |
| 11 | 303.6 | 48 | 145.4 | 112 | 95.3 |
| 11½ | 297.3 | 49 | 144.0 | 115 | 93.9 |
| 12 | 291.3 | 50 | 142.6 | 118 | 92.8 |
| 12½ | 284.7 | 51 | 141.2 | 120 | 92.0 |
| 13 | 276.4 | 52 | 139.8 | 122 | 91.2 |
| 13½ | 274.6 | 53 | 138.5 | 125 | 90.2 |
| 14 | 269.5 | 54 | 137.1 | 130 | 88.4 |
| 14½ | 264.6 | 55 | 135.8 | 135 | 86.8 |
| 15 | 260.5 | 56 | 134.8 | 140 | 85.2 |
| 15½ | 255.8 | 57 | 133.5 | 145 | 83.7 |
| 16 | 252.0 | 58 | 132.3 | 150 | 82.3 |
| 17 | 244.7 | 59 | 131.2 | ... | ..... |
| 18 | 237.5 | 60 | 130.1 | ... | ..... |

## TABLE C.

Multipliers for diameters other than 1 inch.

| | | |
|---|---|---|
| ¼ inch = .0317 | 3 inch = 16.50 | 12 inch = 556 |
| ½ inch = .1810 | 4 inch = 34.10 | 16 inch = 1160 |
| ¾ inch = .5012 | 5 inch = 60.00 | 18 inch = 1570 |
| 1 inch = 1.0000 | 5⅝ inch = 81.00 | 20 inch = 2055 |
| 1½ inch = 2.9300 | 6 inch = 95.00 | 24 inch = 3285 |
| 2 inch = 5.9200 | 8 inch = 198.00 | 30 inch = 5830 |
| 2½ inch = 10.3700 | 10 inch = 350.00 | 36 inch = 9330 |

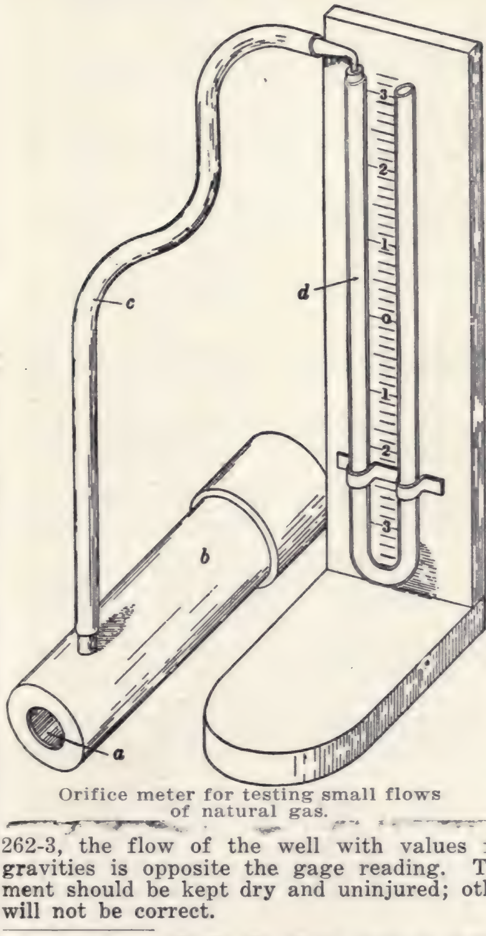
For wrought iron pipes greater than 12 inches in diameter the measure is taken from outside, and for pipes of ordinary thickness the corresponding inside diameters and multipliers are as follows:

Outside dia. of 15-inch pipe gives 14¼ in. inside dia. = 863
Outside dia. of 16-inch pipe gives 15¼ in. inside dia. = 1025
Outside dia. of 18-inch pipe gives 17¼ in. inside dia. = 1410
Outside dia. of 20-inch pipe gives 19¼ in. inside dia. = 1860

# Measuring the Flow of Natural Gas

## ORIFICE METER.

An instrument known as the orifice meter, for testing small flows of natural gas, is shown in the figure. This instrument is simple in construction, consisting of a short 2-inch nipple, b, with pipe thread on one end and a thin plate disk on the other. The disk carries a 1-inch orifice, a, and a hose connection, c, for taking the pressure. The meter is especially intended for testing small gas wells and "casinghead" gas from oil wells. As a rule the flow of gas from an oil well is rather small, and it is not advisable to test the flow with a Pitot tube such as is used in testing large gas wells. In using the orifice tester, it is necessary to know the specific gravity of the gas in order to obtain the flow.



Orifice meter for testing small flows of natural gas.

Before the orifice well tester is attached to the casinghead the well should be permitted to blow into the atmosphere until the head of the gas is reduced and the flow has become normal. Then the tester is attached by simply screwing it into the end of a 3-foot length of 2-inch pipe and the pressure is read in inches of water on the siphon gage, d. In the tables* on pages 262-3, the flow of the well with values for the gas of different gravities is opposite the gage reading. The orifice in the instrument should be kept dry and uninjured; otherwise the gage reading will not be correct.

*Westcott H. P.: Handbook of Natural Gas, 1915, pp. 545-548.

**Capacities of Orifices for Testing Flows of Natural Gas From Small Gas Wells and Casinghead Gas From Oil Wells.**

(Temperature, 60°F.; atmospheric pressure, 14.4 pounds per square inch.)
ONE-INCH ORIFICE IN PLATE ⅛ INCH THICK.

| Pressure | Capacity in Cubic Feet per 24 Hours, at Specific Gravity of— | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.3 | 1.4 | 1.5 |
| ches of Water | | | | | | | | | | | | | | | | |
| ......... | 26,400 | 25,440 | 24,500 | 23,660 | 22,920 | 22,220 | 21,600 | 21,020 | 20,520 | 20,010 | 19,560 | 19,120 | 18,720 | 18,000 | 17,320 | 16,750 |
| ......... | 37,510 | 36,040 | 34,750 | 33,600 | 32,520 | 31,530 | 30,640 | 29,800 | 29,080 | 28,360 | 27,720 | 27,120 | 26,540 | 25,480 | 24,570 | 23,760 |
| ......... | 46,440 | 44,640 | 43,000 | 41,540 | 30,240 | 39,020 | 37,940 | 36,880 | 36,000 | 35,130 | 34,320 | 33,550 | 32,850 | 31,560 | 30,400 | 29,370 |
| ......... | 52,630 | 50,590 | 48,740 | 47,060 | 45,600 | 44,200 | 42,980 | 41,800 | 40,800 | 39,790 | 38,880 | 38,040 | 37,220 | 35,760 | 34,460 | 33,310 |
| ......... | 57,880 | 55,630 | 53,610 | 51,790 | 50,160 | 48,640 | 47,280 | 45,980 | 44,880 | 43,770 | 42,760 | 41,830 | 40,940 | 39,360 | 37,920 | 36,620 |
| ......... | 63,140 | 60,720 | 58,480 | 56,490 | 54,720 | 53,060 | 51,600 | 50,180 | 48,960 | 47,760 | 46,650 | 45,640 | 44,680 | 42,960 | 41,370 | 39,960 |
| ......... | 68,110 | 65,470 | 63,090 | 60,910 | 59,040 | 57,210 | 55,630 | 54,120 | 52,800 | 51,500 | 50,320 | 49,220 | 48,190 | 46,320 | 44,610 | 43,100 |
| ......... | 73,050 | 70,220 | 67,680 | 65,350 | 63,310 | 61,390 | 59,680 | 58,050 | 56,640 | 55,240 | 54,000 | 52,800 | 51,690 | 49,690 | 47,850 | 46,220 |
| ......... | 77,680 | 74,680 | 72,000 | 69,500 | 67,340 | 65,280 | 63,480 | 61,720 | 60,240 | 58,800 | 57,430 | 56,160 | 54,960 | 52,800 | 50,880 | 49,170 |
| ......... | 82,340 | 79,150 | 76,270 | 73,650 | 71,370 | 69,190 | 67,270 | 65,420 | 63,840 | 62,280 | 60,860 | 59,520 | 58,240 | 55,900 | 53,920 | 52,100 |
| ......... | 86,680 | 83,320 | 80,300 | 77,540 | 75,120 | 72,840 | 70,800 | 68,880 | 67,200 | 65,560 | 64,080 | 62,660 | 61,320 | 58,920 | 56,780 | 54,860 |
| ......... | 90,720 | 87,190 | 84,000 | 81,140 | 78,600 | 76,220 | 74,110 | 72,000 | 70,320 | 68,610 | 67,030 | 65,560 | 64,170 | 61,680 | 59,400 | 57,400 |
| ches of lercury | | | | | | | | | | | | | | | | |
| ½......... | 67,200 | 64,600 | 62,300 | 60,100 | 58,200 | 56,500 | 54,900 | 53,400 | 52,100 | 50,800 | 49,600 | 48,600 | 47,500 | 45,700 | 44,000 | 42,500 |
| ......... | 95,200 | 91,500 | 88,200 | 85,100 | 82,500 | 80,000 | 77,800 | 75,600 | 73,800 | 72,000 | 70,300 | 68,800 | 67,300 | 64,700 | 62,300 | 60,200 |
| ½......... | 116,600 | 112,000 | 108,000 | 104,300 | 101,000 | 97,900 | 95,300 | 92,600 | 90,400 | 88,200 | 86,200 | 84,300 | 82,500 | 79,200 | 76,300 | 73,800 |
| ......... | 134,600 | 129,400 | 124,700 | 120,400 | 116,700 | 113,100 | 110,000 | 107,000 | 104,400 | 101,800 | 99,500 | 97,300 | 95,300 | 91,500 | 88,200 | 85,200 |
| ½......... | 145,600 | 139,900 | 134,900 | 130,200 | 126,200 | 122,400 | 118,900 | 115,700 | 112,900 | 110,100 | 107,600 | 105,300 | 103,000 | 99,000 | 95,400 | 92,200 |
| ......... | 164,900 | 158,500 | 152,700 | 147,500 | 142,900 | 138,600 | 134,700 | 131,000 | 127,800 | 124,700 | 121,800 | 119,200 | 116,600 | 112,000 | 108,000 | 104,300 |
| ½......... | 178,200 | 171,300 | 165,100 | 159,400 | 154,500 | 149,800 | 145,600 | 141,600 | 138,200 | 134,800 | 131,700 | 128,800 | 126,100 | 121,200 | 116,700 | 112,800 |
| ......... | 190,400 | 183,000 | 176,400 | 170,300 | 165,000 | 160,000 | 155,600 | 151,300 | 147,600 | 144,000 | 140,700 | 137,600 | 134,700 | 129,400 | 124,700 | 120,500 |
| ......... | 212,900 | 204,600 | 197,200 | 190,400 | 184,500 | 178,900 | 174,000 | 169,200 | 165,000 | 161,000 | 157,300 | 153,900 | 150,600 | 144,700 | 139,400 | 134,700 |
| ......... | 233,200 | 224,100 | 216,000 | 208,600 | 202,100 | 195,900 | 190,500 | 185,300 | 180,800 | 176,400 | 172,300 | 168,600 | 165,000 | 158,500 | 152,700 | 147,600 |
| ......... | 251,900 | 242,100 | 233,400 | 225,300 | 218,300 | 211,700 | 205,800 | 200,200 | 195,300 | 190,000 | 186,200 | 182,100 | 178,200 | 171,200 | 165,000 | 159,400 |
| ......... | 269,400 | 258,900 | 249,500 | 240,900 | 233,400 | 226,400 | 220,100 | 214,000 | 208,800 | 203,700 | 199,100 | 194,700 | 190,600 | 183,100 | 176,400 | 170,560 |
| ......... | 285,700 | 274,600 | 264,700 | 255,600 | 247,600 | 240,100 | 233,500 | 227,000 | 221,500 | 216,100 | 211,200 | 206,500 | 202,100 | 194,200 | 187,100 | 180,800 |
| ......... | 301,200 | 289,500 | 279,000 | 269,400 | 261,000 | 253,100 | 246,100 | 239,300 | 233,500 | 227,800 | 222,600 | 217,700 | 213,100 | 204,700 | 197,300 | 190,600 |
| ......... | 315,800 | 303,600 | 292,500 | 282,500 | 273,700 | 265,400 | 258,000 | 250,900 | 244,800 | 238,900 | 233,400 | 228,300 | 223,400 | 214,700 | 206,800 | 199,900 |
| ......... | 328,400 | 315,700 | 304,200 | 293,800 | 284,600 | 276,000 | 268,400 | 261,000 | 254,600 | 248,400 | 242,700 | 237,400 | 232,400 | 223,300 | 215,100 | 207,900 |

## Capacities of Orifices for Testing Flows of Natural Gas From Small Gas Wells and Casinghead Gas From Oil Wells.—Continued.

ONE-HALF INCH ORIFICE IN PLATE ⅛ INCH THICK.

| Pressure | Capacity in Cubic Feet per 24 Hours, at Specific Gravity of— | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.3 | 1.4 | 1.5 |
| ches of Water | | | | | | | | | | | | | | | | |
| ½ | 4,490 | 4,320 | 4,160 | 4,020 | 3,890 | 3,770 | 3,670 | 3,570 | 3,480 | 3,400 | 3,320 | 3,250 | 3,180 | 3,050 | 2,940 | 2,840 |
| | 6,200 | 6,010 | 5,790 | 5,600 | 5,440 | 5,260 | 5,110 | 4,970 | 4,850 | 4,730 | 4,620 | 4,520 | 4,420 | 4,250 | 4,100 | 3,960 |
| ½ | 7,900 | 7,590 | 7,310 | 7,070 | 6,840 | 6,640 | 6,450 | 6,280 | 6,120 | 5,970 | 5,830 | 5,710 | 5,590 | 5,370 | 5,170 | 5,000 |
| | 9,140 | 8,780 | 8,460 | 8,170 | 7,910 | 7,680 | 7,460 | 7,260 | 7,080 | 6,910 | 6,750 | 6,600 | 6,460 | 6,210 | 5,980 | 5,780 |
| ½ | 10,220 | 9,820 | 9,470 | 9,140 | 8,850 | 8,590 | 8,350 | 8,120 | 7,920 | 7,730 | 7,550 | 7,380 | 7,230 | 6,950 | 6,690 | 6,470 |
| | 11,150 | 10,720 | 10 330 | 9,980 | 9,660 | 9,370 | 9,110 | 8,860 | 8,640 | 8,430 | 8,240 | 8,060 | 7,890 | 7,580 | 7,300 | 7,050 |
| ½ | 12,020 | 11,550 | 11,130 | 10,750 | 10,410 | 10,100 | 9,810 | 9,550 | 9,310 | 9,090 | 8,880 | 8,680 | 8,500 | 8,170 | 7,870 | 7,600 |
| | 12,800 | 12,290 | 11,850 | 11,440 | 11,080 | 10,750 | 10,450 | 10,170 | 9,910 | 9,670 | 9,450 | 9,240 | 9,050 | 8,690 | 8,380 | 8,090 |
| ½ | 13,480 | 12,950 | 12,480 | 12,050 | 11,670 | 11,320 | 11,000 | 10,710 | 10,440 | 10,190 | 9,950 | 9,730 | 9,530 | 9,160 | 8,820 | 8,520 |
| | 14.130 | 13,570 | 13,080 | 12,640 | 12,230 | 11,870 | 11,530 | 11,230 | 10,940 | 10,680 | 10,430 | 10,200 | 9,990 | 9,600 | 9,250 | 8,930 |
| ½ | 14,690 | 14,110 | 13,600 | 13,130 | 12,720 | 12,340 | 11,990 | 11,670 | 11,380 | 11,100 | 10,850 | 10,610 | 10,380 | 9,989 | 9,610 | 9,290 |
| | 15,210 | 14,620 | 14,080 | 13,610 | 13,170 | 12,780 | 12,420 | 12,090 | 11,780 | 11,500 | 11,230 | 10,990 | 10,760 | 10,330 | 9,960 | 9,620 |

THREE-EIGHTHS INCH ORIFICE IN PLATE ⅛ INCH THICK.

| Pressure | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.3 | 1.4 | 1.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ½ | 2,270 | 2,180 | 2,100 | 2,030 | 1.970 | 1,910 | 1,850 | 1,810 | 1,760 | 1,720 | 1,680 | 1,640 | 1,610 | 1,540 | 1,490 | 1,410 |
| | 3,460 | 3,320 | 3 200 | 3,090 | 3,000 | 2,910 | 2.820 | 2,750 | 2,680 | 2,670 | 2,550 | 2,500 | 2,450 | 2,350 | 2,260 | 2,190 |
| ½ | 4,310 | 4,140 | 3,990 | 3,860 | 3,730 | 3,620 | 3,520 | 3,420 | 3,339 | 3,260 | 3,180 | 3,110 | 3,050 | 2,430 | 2,820 | 2,730 |
| | 4,830 | 4,640 | 4,470 | 4,320 | 4,180 | 4,060 | 3,910 | 3,840 | 3,740 | 3,650 | 3,500 | 3,490 | 3,410 | 3,280 | 3,160 | 3,950 |
| ½ | 5,400 | 5,190 | 5,000 | 4,830 | 4,680 | 4,540 | 4,410 | 4,290 | 4,186 | 4,080 | 3,990 | 3,900 | 3,820 | 3,670 | 3,540 | 3,420 |
| | 5,770 | 5,550 | 5,350 | 5,170 | 5,000 | 4,850 | 4,720 | 4,590 | 4,474 | 4,370 | 4,260 | 4,170 | 4,080 | 3,920 | 3,780 | 3,650 |
| ½ | 6,290 | 6,050 | 5,830 | 5,630 | 5,450 | 5,290 | 5,140 | 5,000 | 4,875 | 4,760 | 4,650 | 4,550 | 4,450 | 4,270 | 4,120 | 3,980 |
| | 6.650 | 6,390 | 6,160 | 5,950 | 5,760 | 5,590 | 5,430 | 5,280 | 5,152 | 5,030 | 4,910 | 4,800 | 4,700 | 4,520 | 4,350 | 4,210 |
| ½ | 7,210 | 6,930 | 6,680 | 6,450 | 6,240 | 6,060 | 5,890 | 5,730 | 5,585 | 5,450 | 5,330 | 5,210 | 5,100 | 4,900 | 4,720 | 4,560 |
| 5 | 7,680 | 7,380 | 7.110 | 6,870 | 6,650 | 6,450 | 6.270 | 6,100 | 5,946 | 5,800 | 5.670 | 5,540 | 5,430 | 5,210 | 5,020 | 4,850 |
| 5½ | 8,100 | 7,790 | 7,500 | 7,250 | 7,020 | 6,810 | 6,620 | 6,440 | 6,278 | 6,130 | 5,980 | 5,850 | 5,730 | 5,510 | 5,310 | 5,130 |
| | 8,290 | 7,970 | 7,680 | 7,420 | 7,180 | 6,970 | 6,770 | 6,590 | 6,423 | 6,270 | 6,120 | 5,990 | 5,860 | 5,630 | 5,430 | 5,240 |

# Orifice Capacity

| Diameter Inches | | Area | Morse Drill Gage Size | Cubic Feet Per Hour | | |
|---|---|---|---|---|---|---|
| Frac. | Decimal | Square Inch | | Coal Gas 0.43 sp. gr. 2″ Press | Water Gas 0.62 sp. gr. 2″ Press | Natural Gas 0.62 sp. gr. 4½ Oz. Press |
| | 0.0135 | 0.000143 | 80 | 1.04 | 0.86 | 1.67 |
| | 0.0145 | 0.000165 | 79 | 1.16 | 0.97 | 1.89 |
| 1/64 | 0.0156 | 0.00019 | ........ | 1.26 | 1.05 | 2.05 |
| | 0.016 | 0.00020 | 78 | 1.32 | 1.10 | 2.14 |
| | 0.018 | 0.00025 | 77 | 1.35 | 1.13 | 2.20 |
| | 0.020 | 0.00031 | 76 | 1.62 | 1.35 | 2.63 |
| | 0.021 | 0.00035 | 75 | 1.80 | 1.52 | 2.96 |
| | 0.0225 | 0.00040 | 74 | 2.16 | 1.80 | 3.51 |
| | 0.024 | 0.00045 | 73 | 2.29 | 1.90 | 3.70 |
| | 0.025 | 0.00049 | 72 | 2.46 | 2.05 | 4.00 |
| | 0.026 | 0.00053 | 71 | 2.70 | 2.25 | 4.38 |
| | 0.028 | 0.00062 | 70 | 2.79 | 2.33 | 4.54 |
| | 0.0292 | 0.00067 | 69 | 3.08 | 2.57 | 4.97 |
| | 0.031 | 0.00075 | 68 | 3.23 | 2.70 | 5.26 |
| 1/32 | 0.031 | 0.00076 | ........ | 3.26 | 2.73 | 5.32 |
| | 0.032 | 0.00080 | 67 | 3.42 | 2.85 | 5.56 |
| | 0.033 | 0.00086 | 66 | 3.53 | 2.94 | 5.73 |
| | 0.035 | 0.00096 | 65 | 3.69 | 3.08 | 6.00 |
| | 0.036 | 0.00102 | 64 | 3.86 | 3.23 | 6.30 |
| | 0.037 | 0.00108 | 63 | 4.05 | 3.38 | 6.60 |
| | 0.038 | 0.00113 | 62 | 4.11 | 3.51 | 6.84 |
| | 0.039 | 0.00119 | 61 | 4.50 | 3.75 | 7.31 |
| | 0.040 | 0.00126 | 60 | 4.95 | 4.12 | 8.04 |
| | 0.041 | 0.00132 | 59 | 5.22 | 4.35 | 8.48 |
| | 0.042 | 0.00138 | 58 | 5.40 | 4.50 | 8.77 |
| | 0.043 | 0.00145 | 57 | 5.67 | 4.71 | 9.2 |
| | 0.0465 | 0.00170 | 56 | 6.57 | 5.47 | 10.6 |
| 3/64 | 0.0469 | 0.00173 | ........ | 6.75 | 5.63 | 11.0 |
| | 0.0520 | 0.0021 | 55 | 8.9 | 6.75 | 13.2 |
| | 0.0550 | 0.0023 | 54 | 9.0 | 7.50 | 14.6 |
| | 0.0595 | 0.0028 | 53 | 10.8 | 9.0 | 17.5 |
| 1/16 | 0.0625 | 0.0031 | ........ | 11.7 | 9.7 | 19.0 |
| | 0.0635 | 0.0032 | 52 | 11.9 | 9.9 | 19.3 |
| | 0.0670 | 0.0035 | 51 | 12.6 | 10.5 | 20.5 |
| | 0.070 | 0.0038 | 50 | 13.5 | 11.2 | 21.8 |
| | 0.0730 | 0.0042 | 49 | 14.4 | 12.0 | 23.4 |
| | 0.076 | 0.0043 | 48 | 15.3 | 12.7 | 24.8 |
| 5/64 | 0.0781 | 0.0048 | ........ | 15.7 | 13.1 | 25.5 |
| | 0.0785 | 0.0018 | 47 | 15.8 | 13.2 | 25.7 |
| | 0.081 | 0.0051 | 46 | 16 | 13.5 | 26 |
| | 0.082 | 0.0053 | 45 | 17 | 14.3 | 28 |
| | 0.086 | 0.0058 | 44 | 18 | 15 | 29 |
| | 0.089 | 0.0062 | 43 | 19 | 16.5 | 32 |
| | 0.0935 | 0.0069 | 42 | 20 | 17 | 33 |
| 3/32 | 0.0937 | 0.0069 | ........ | 21 | 18 | 35 |
| | 0.096 | 0.0072 | 41 | 22 | 19 | 37 |
| | 0.098 | 0.0075 | 40 | 23 | 20 | 39 |
| | 0.0995 | 0.0078 | 39 | 24 | 20.5 | 40 |
| | 0.1015 | 0.0081 | 38 | 25 | 21 | 41 |
| | 0.104 | 0.0085 | 37 | 26 | 22 | 43 |
| | 0.1065 | 0.0090 | 36 | 27 | 22.5 | 44 |
| 7/64 | 0.1093 | 0.0094 | ........ | 28 | 23 | 45 |
| | 0.110 | 0.0095 | 35 | 29 | 24 | 47 |
| | 0.111 | 0.0097 | 34 | 30 | 25 | 49 |
| | 0.113 | 0.0100 | 33 | 31 | 26 | 51 |
| | 0.116 | 0.0106 | 32 | 32 | 27 | 53 |

## ORIFICE CAPACITY—Continued.

| Diameter Inches | | Area | Morse Drill Gage Size | Cubic Feet Per Hour | | |
|---|---|---|---|---|---|---|
| Frac. | Decimal | Square Inch | | Coal Gas 0.43 sp. gr. 2″ Press | Water Gas 0.62 sp. gr. 2″ Press | Natural Gas 0.62 sp. gr. 4½ Oz. Press |
| | 0.120 | 0.0113 | 31 | 33 | 28 | 55 |
| 1/8 | 0.125 | 0.0123 | ........ | 36 | 30 | 58 |
| | 0.1285 | 0.0130 | 30 | 39 | 32 | 62 |
| | 0.136 | 0.0145 | 29 | 43 | 35 | 68 |
| | 0.1405 | 0.0155 | 28 | 44 | 37 | 72 |
| 9/64 | 0.1406 | 0.0155 | ........ | 45 | 38 | 74 |
| | 0.144 | 0.0163 | 27 | 47 | 39 | 76 |
| | 0.147 | 0.0174 | 26 | 48 | 40 | 78 |
| | 0.1495 | 0.0175 | 25 | 51 | 42 | 82 |
| | 0.152 | 0.0181 | 24 | 52 | 43 | 84 |
| | 0.154 | 0.0186 | 23 | 53 | 44 | 86 |
| 5/32 | 0.156 | 0.0192 | ........ | 54 | 45 | 88 |
| | 0.157 | 0.0192 | 22 | 55 | 46 | 90 |
| | 0.159 | 0.0198 | 21 | 57 | 47 | 91 |
| | 0.161 | 0.0203 | 20 | 58 | 48 | 94 |
| | 0.166 | 0.0216 | 19 | 60 | 50 | 97 |
| | 0.1695 | 0.0226 | 18 | 62 | 52 | 101 |
| 11/64 | 0.1719 | 0.0232 | ........ | 63 | 53 | 103 |
| | 0.173 | 0.0235 | 17 | 65 | 54 | 105 |
| | 0.177 | 0.0246 | 16 | 68 | 56 | 109 |
| | 0.180 | 0.0254 | 15 | 69 | 58 | 113 |
| | 0.182 | 0.0260 | 14 | 71 | 59 | 115 |
| | 0.185 | 0.0269 | 13 | 72 | 61 | 119 |
| 3/16 | 0.1875 | 0.0276 | ........ | 75 | 62 | 121 |
| | 0.189 | 0.0280 | 12 | 76 | 63 | 123 |
| | 0.191 | 0.0286 | 11 | 77 | 64 | 125 |
| | 0.1935 | 0.0294 | 10 | 79 | 66 | 129 |
| | 0.196 | 0.0302 | 9 | 80 | 67 | 131 |
| | 0.199 | 0.0311 | 8 | 83 | 69 | 134 |
| | 0.201 | 0.0317 | 7 | 84 | 70 | 136 |
| 13/64 | 0.203 | 0.0324 | ........ | 86 | 71 | 138 |
| | 0.204 | 0.0327 | 6 | 87 | 72 | 140 |
| | 0.205 | 0.0332 | 5 | 89 | 74 | 144 |
| | 0.209 | 0.0343 | 4 | 93 | 77 | 150 |
| | 0.213 | 0.0356 | 3 | 95 | 79 | 154 |
| 7/32 | 0.2187 | 0.0375 | ........ | 97 | 80 | 156 |
| | 0.221 | 0.0384 | 2 | 99 | 82 | 160 |
| | 0.228 | 0.0408 | 1 | 104 | 86 | 168 |
| 15/64 | 0.2344 | 0.0442 | ........ | 108 | 90 | 175 |
| 1/4 | 0.250 | 0.0491 | ........ | 119 | 99 | 193 |
| 17/64 | 0.2656 | 0.0554 | ........ | 131 | 109 | 212 |
| 9/32 | 0.2812 | 0.0621 | ........ | 142 | 119 | 232 |
| 19/64 | 0.2969 | 0.0692 | ........ | 153 | 128 | 250 |
| 5/16 | 0.3125 | 0.0767 | ........ | 164 | 136 | 265 |
| 21/64 | 0.3281 | 0.0845 | ........ | 176 | 146 | 285 |
| 11/32 | 0.3437 | 0.0928 | ........ | 187 | 155 | 302 |
| 23/64 | 0.3594 | 0.1014 | ........ | 198 | 165 | 322 |
| 3/8 | 0.375 | 0.1104 | ........ | 209 | 174 | 340 |
| 25/64 | 0.3906 | 0.1198 | ........ | 221 | 184 | 360 |
| 13/32 | 0.4062 | 0.1296 | ........ | 231 | 193 | 376 |
| 27/64 | 0.4219 | 0.1398 | ........ | 241 | 201 | 392 |
| 7/16 | 0.4375 | 0.1503 | ........ | 254 | 211 | 412 |
| 29/64 | 0.4531 | 0.1612 | ........ | 264 | 220 | 430 |
| 15/32 | 0.4687 | 0.1725 | ........ | 277 | 230 | 448 |
| 31/64 | 0.4844 | 0.1843 | ........ | 286 | 239 | 466 |
| 1/2 | 0.500 | 0.1963 | ........ | 299 | 249 | 485 |
| 33/64 | 0.5156 | 0.2088 | ........ | 309 | 257 | 500 |
| 17/32 | 0.5312 | 0.2216 | ........ | 320 | 267 | 520 |
| 35/64 | 0.5469 | 0.2349 | ........ | 331 | 276 | 539 |
| 9/16 | 0.5625 | 0.2485 | ........ | 340 | 285 | 556 |
| 37/64 | 0.5781 | 0.2625 | ........ | 353 | 295 | 576 |
| 19/32 | 0.5937 | 0.2769 | ........ | 365 | 303 | 590 |

## ORIFICE CAPACITY—Continued.

| Diameter Inches | | Area | Morse Drill Gage Size | Cubic Feet Per Hour | | |
|---|---|---|---|---|---|---|
| Frac. | Decimal | Square Inch | | Coal Gas 0.43 sp. gr. 2″ Press | Water Gas 0.62 sp. gr. 2″ Press | Natural Gas 0.62 sp. gr. 4½ Oz. Press |
| 39/69 | 0.6094 | 0.2917 | ........ | 376 | 313 | 610 |
| 5/8 | 0.625 | 0.3068 | ........ | 387 | 323 | 630 |
| 41/64 | 0.6406 | 0.3223 | ........ | 399 | 333 | 650 |
| 21/32 | 0.6562 | 0.3382 | ........ | 410 | 341 | 665 |
| 43/64 | 0.0719 | 0.3546 | ........ | 421 | 350 | 682 |
| 11/16 | 0.6875 | 0.3712 | ........ | 431 | 369 | 720 |
| 45/64 | 0.7031 | 0.3883 | ........ | 443 | 370 | 722 |
| 23/32 | 0.7187 | 0.4057 | ........ | 454 | 378 | 737 |
| 47/64 | 0.7344 | 0.4236 | ........ | 466 | 387 | 755 |
| 3/4 | 0.750 | 0.4418 | ........ | 476 | 397 | 774 |
| 49/64 | 0.7656 | 0.4604 | ........ | 488 | 406 | 792 |
| 25/32 | 0.7812 | 0.4794 | ........ | 499 | 415 | 810 |
| 51/64 | 0.7969 | 0.4988 | ........ | 510 | 424 | 827 |
| 13/16 | 0.8125 | 0.5185 | ........ | 520 | 433 | 845 |
| 53/64 | 0.8281 | 0.5386 | ........ | 532 | 443 | 865 |
| 27/32 | 0.8438 | 0.5591 | ........ | 543 | 453 | 884 |
| 25/64 | 0.8594 | 0.5801 | ........ | 554 | 461 | 900 |
| 7/8 | 0.875 | 0.6013 | ........ | 565 | 472 | 920 |
| 57/64 | 0.8906 | 0.6229 | ........ | 576 | 480 | 938 |
| 29/32 | 0.9062 | 0.6450 | ........ | 588 | 490 | 955 |
| 59/64 | 0.9219 | 0.6675 | ........ | 599 | 500 | 976 |
| 15/16 | 0.9375 | 0.6903 | ........ | 510 | 507 | 985 |
| 61/64 | 0.9531 | 0.7134 | ........ | 620 | 517 | 1010 |
| 31/32 | 0.9687 | 0.7371 | ........ | 632 | 526 | 1025 |
| 63/64 | 0.9844 | 0.7611 | ........ | 644 | 536 | 1047 |
| 1 | 1.0000 | 0.7854 | ........ | 655 | 545 | 1062 |

NOTE:—The above table is based upon data obtained from gas orifices that are ordinarily used in gas appliances such as the ones used in Hale Gas Mixers.

ARTIFICIAL GAS:—The above figures are based upon 2-inch pressure; for higher pressures these figures should be increased by a percentage as shown below:

3-inch = 25 %
4-inch = 50
5-inch = 62.5
6-inch = 75
7-inch = 87.5
10-inch = 120
12-inch = 140
16-inch = 180
20-inch = 210

NATURAL GAS:—The above figures for natural gas are based on a gas under 4½ oz. pressure having a specific gravity of 0.62, which is the ordinary gravity of natural gas sold in cities supplied by gas from the Mid Continent, Pennsylvania and West Virginia fields. When the pressure is greater than 4½ oz. the figures in the table should be increased as shown below:

5 oz. = 10%
6 oz. = 20
7 oz. = 30
8 oz. = 39
9 oz. = 47.5
10 oz. = 60

# Outline of Methods of Analysis of Petroleum Products

1. Specific Gravity and Baume' Gravity.
   A. With the hydrometer for fluid petroleum products.
   B. With the picnometer.
   C. With the Westphal balance.
   D. For asphalt and semi-solid petroleum products by fluid suspension.
   E. For rigid asphalt surface mixtures.
2. Color of Petroleum.
   A. By the Saybolt Chromometer.
   B. By the Lovibond Tintometer.
   C. With Potassium Bichromate solutions.
   D. With Iodine solutions.
3. Odor of oil.
4. Transparency.
5. Viscosity or Fluidity.
   A. With the Saybolt Universal Viscosimeter (A. S. T. M.), the Engler and the Redwood.
   B. Ubbelohde Viscosimeter for thin petroleum products.
   C. MacMichael disk friction viscosimeter.
   D. Float test for viscosity of road oils.
   E. Zero Viscosity for semi-solid petroleum products.
6. Melting Point.
   A. Ring and Ball Method (A. S. T. M.).
   B. Cube Method.
   C. "General Electric" method.
   D. Titer method for wax.
7. Cold Test.
   A. Cloud test.
   B. Pour test.
   C. Cold test.
8. Water and Bottom Settlings.
   A. By centrifuge.
   B. By distillation.
9. Distillation tests of Petroleum.
   A. Proximate distillation for water, gasoline, kerosene and residuum.
   B. End point distillation (A. S. T. M. and Bureau of Mines).
   C. Fractional—Gravity distillation analysis.
   D. Fractional—Sample distillation.
10. Flash and Burning Points.
   A. Illuminating oils with closed tester.
      (Standard A. S. T. M.—"Tag" tester.)
   B. All types of Petroleum products with the Elliott or New York closed tester.
   C. Lubricants and asphalt with Cleveland open cup.
11. Pressure—heat tests.
   A. Cracking test under high pressure and temperature.
   B. Vapor pressure test at high pressure.
   C. Vapor pressure of casinghead and light gasoline.

12. Carbon residue.
    A. Conradson Carbon test (A. S. T. M.).
    B. Fixed carbon and ash in asphalt.
13. Emulsification test of lubricating oils.
14. Heat of combustion.
    A. By bomb calorimeter.
    B. By calculation from gravity.
15. Sulphur in petroleum products.
    A. By bomb calorimeter.
    B. By Eschka method.
    C. By Parr chemical bomb.
16. Ultimate Analysis.
    A. Carbon and Hydrogen.
    B. Nitrogen.
17. Doctor test for refined distillates.
18. Olefins, ethylenes or unsaturated hydrocarbons.
    A. Babcock method (B. of M.).
    B. Cylinder method (Egloff).
    C. Refining loss.
19. Aromatic and paraffin hydrocarbons in petroleum.
    A. Nitrating method.
    B. Distillation method.
20. Free acid in petroleum products.
21. Floc test.
22. Corrosion and Gumming test of gasoline.
23. Penetration or Consistency of asphalt.
24. Ductility of asphalt.
25. Resistance of asphalt and oil to evaporation.
26. Determination of natural asphalt or semi-solid hydrocarbons in petroleum.
27. Solubility of asphalt.
    A. In Petroleum ether—Petrolenes and Asphaltenes.
    B. In Carbon bisulphide—total bitumen.
    C. In Carbon tetrachloride—non-carbenes.
28. Resistance of asphalt to oxidation.
29. Paraffin wax or scale determination.
30. Bitumen and grading of asphalt-mineral mixtures.
    A. By burning.
    B. By extraction.
31. Tensile and Cementing strength of asphaltic surface mixture.
32. Specific Gravity of Gas.
    A. Effusion or Viscosity method.
    B. Edwards Gas balance.
33. Gasoline determination in gas (see also specific gravity).
    A. By absorption test.
    B. Freezing test.
34. Complete Chemical Analysis of Gas with preparation of reagents.
35. Heat of Combustion of Gas.
    A. By the calorimeter.
    B. By oxygen consumption.
    C. By calculation from chemical analysis.

Note.—The Kansas City Testing Laboratory will give information to anyone concerning supply houses from whom any of the following oil testing instruments may be obtained.

# Index to Applications of Methods of Analysis

| Product | Routine test | Occasional test | Rarely used | Can be used but not specially adapted |
|---|---|---|---|---|
| A. Crude Petroleum | 1, 2, 3, 4, 8, 9A | 5A, 9C, 14 15, 26, 29 | 2D, 7B, 9D, 10B, 16, 18 | 5D, 9B, 11, 12, 13, 19, 25 |
| B. Gasoline, Benzine and Naphtha .... | 1, 2, 3, 4, 9B, 11C 17, 18, 22 | 9C, 14, 19, 20 | 5B, 7A, 15, 16 | 9D, 10 |
| C. Kerosene and Illuminating Oils ........ | 1, 2, 3, 4, 5B, 7, 9B 10A, 15, 17, 21 | 10B, 14A, 20, 22 | 9C, 11B, 16, 18, 19 | 12A, 13 |
| D. Gas Oil, Straw Oil, Absorption Oil ..... | 1, 2, 3, 4, 7, 9C, 10 14, 15 | 5, 11A, 12A, 13, 17, 18 | 16, 19, 20, 21 | |
| E. Lubricants, Paraffin Oil.. | 1, 2, 3, 4, 5A, 7, 10 12A, 13 15, 20 | 14, 17, 18 | 16, 19, 21 | 9, 11, 22 |
| F. Fuel Oil, Diesel Engine Oil ... | 1, 4, 7, 8, 10, 14, 15 | 5, 11, 26 27A, 29 | 2D, 3, 9, 12, 16, 18, 19 | 13 |
| G. Road Oil, Flux Oil ......... | 1AB, 3, 5AD, 8, 10, 12, 25, 26, 27 | 7B, 14, 15, 29 | 2D, 11, 16 | 13, 28, 5A |
| H. Asphalt and Pitch ....... | 1D, 5E, 6, 8B, 12, 23, 24, 25, 27 | 10, 15, 28, 29 | 2D, 3, 14 16 | 5A |
| I. Wax .......... | 1D, 2, 3, 4 6D | 25 | 11A, 12A, 14, 15, 16, 17, 18, 19, 20 | 7A, 10 |
| J. Grease ........ | 1, 2, 3, 4, 5CDE, 8, 12B, 27 | 25 | 16 | 6, 7, 10 |
| K. Asphalt Surface Mix ......... | 1E, 30, 31 | | | |
| L. Gas ........... | 32, 33, 34, 35 | 16 | | |

Note:—See special specifications for other tests of Petroleum Products.

**1. Specific Gravity and Baume' Gravity.**

A. With the hydrometer.

Specific gravity is the relation by weight of the same volume of oil and of water. Unless some other temperature is specifically mentioned the gravity refers to 60°F. Specific gravity is determined by means of the hydrometer, the Westphal balance, the picnometer and by displacement methods. The absolute specific gravity scale is not commonly used in the oil industry. Instead, the Baume' gravity scale, an entirely arbitrary standard, is used. Two Baume' gravity scales are in use in the oil industry; one is that adopted by the U. S. Bureau of Standards and its relation to specific gravity is indicated by the following formula:

$$\text{Specific Gravity} = \frac{140}{130 + \text{Baume}'^{\circ}}$$ for liquids lighter than water.

Another scale possibly more commonly used is that of instruments made by the Tagliabue Mfg. Co., which is based upon the following relation to specific gravity:

$$\text{Specific Gravity} = \frac{141.5}{131.5 + \text{Baume}'^{\circ}}$$ for liquids lighter than water.

The difference between the two readings varies from nothing with very heavy oils to as much as 0.5°Be' for ordinary gasoline. When the oil is heavier than water a different formula is used for calculating the Baume' gravity, the following being in general use:

$$\text{Degrees Baume}' = 145 - \frac{145}{\text{Specific Gravity}}$$ for liquids heavier than water.

Oils heavier than water are not commonly encountered. The method of using the hydrometer is the same in all cases whether its reading is in terms of the U. S. Bureau of Standards Baume' scale, the Tagliabue Baume' scale, Baume' scale for liquids heavier than water, or for direct specific gravity. The ideal instrument for all purposes is of course that reading directly in specific gravity. By the use of tables these readings can be converted into the Baume' reading desired and without any misunderstanding as to which scale is intended.

The correct method of reading the hydrometer is illustrated in Figs. 1 and 2, page 275. The sample of oil is placed in a clear jar or cylinder and the hydrometer carefully immersed in it to a point slightly below that to which it naturally sinks and is then allowed to float freely. The reading should not be taken until the oil and the hydrometer are free from air bubbles and are at rest.

In taking the reading the eye should be placed slightly below the plane of the surface of the oil (Fig. 1) and then raised slowly until this surface, seen as an ellipse, becomes a straight line (Fig. 2). The point at which this line cuts the hydrometer scale should be taken as the reading of the instrument (Fig. 2).

In case the oil is not sufficiently clear to allow the reading to be made as above described, it will be necessary to read from above the oil surface and to estimate as accurately as possible the point to which the oil rises on the hydrometer stem. It should be remembered, however, that the instrument is calibrated to give correct indications when read at the principal surface of the liquid. It will be necessary, therefore, to correct the reading at the upper meniscus by an amount equal

to the height to which the oil creeps up on the stem of the hydrometer. The amount of this correction may be determined with sufficient accuracy for most purposes by taking a few readings on the upper and the lower meniscus in a clear oil and noting the differences.

A specific gravity hydrometer will read too low and a Baume' hydrometer too high when read at the upper edge of the meniscus. The correction for meniscus height should therefore be added to a specific gravity reading and subtracted from a Baume' reading.

The magnitude of the correction will obviously depend upon the length and value of the subdivisions of the hydrometer scale and must be determined in each case for the particular hydrometer in question.

Specific gravity and Baume' gravity readings of oil are conveniently taken at room temperature and these readings must be converted to the gravity at 60°F. As a general rule it may be said that petroleum oil expands with heat so that 0.0004 must be added as a correction to the specific gravity readings for each degree Fahr. that the oil is above 60°F or must be subtracted for each degree Fahr. below 60°F. On the Baume' scale .1°Be' may be subtracted for each degree Fahr. above 60°F or added for each degree Fahr. below 60°F. For exact temperature corrections for specific gravity, see pages 334 to 418. For exact temperature corrections for Baume' gravity, see pages 376-383. For conversions of Baume' to and from specific gravity, see pages 370-375.

1B. **Specific Gravity** with the picnometer.

Various types of picnometers may be used for this purpose, each of which has special advantages. Some are plain bottles with capillary openings in a well made ground glass stopper; others have graduated tubes in the stoppers, vacuum walls and inserted thermometers. The Sprengel picnometer is particularly adapted to the handling of very viscous oils as it prevents the including of air bubbles in the instrument. With any of the various types the perfectly dry and clean picnometer is weighed at 60°F to the nearest 0.0001 gram. It is filled with distilled water at 60°F and weighed. It is then dried completely and filled with the oil to be tested at 60°F. The net weight of the oil divided by the net weight of the distilled water gives the specific gravity of the oil. For conversion into degrees Baume' the formulae given on page 272 or the tables given on pages 370 to 375 are used.

1C. **Specific Gravity** with the Westphal balance.

This is a very convenient instrument where a great variety of petroleum products are to be tested as it covers any range of specific gravity and can be used for practically any type of material. Its character is shown by the figures on page 273. The oil is put into the jar and the weights or riders are adjusted on the beam until the pointer is in exact poise. The readings are in specific gravity based on a water temperature of 60°F at which temperature the instrument is standardized. The specific gravity may be converted to Baume' scale with the tables.

1D. **Specific Gravity** for semi-solid petroleum materials.

A convenient method of taking the specific gravity of asphaltic cement and similar semi-solid petroleum materials is the following (see upper figure on page 277). Roll up a ball of the asphalt about 1 cm. in diameter, being careful that no water is included. Place this in a cylinder of cold distilled water from which the air has been removed by previous boiling. If the ball of asphalt floats, denatured alcohol is added until it shows no tendency to go either up or down when placed in the middle of the cylinder. The specific gravity of the liquid is then taken with the Westphal balance or with the hydrometer. If the ball of asphalt sinks a saturated solution of sodium chloride or common salt is added until the asphalt when placed in the center of the cylinder shows no tendency to go either up or down. The specific gravity is taken with a hydrometer for liquids heavier than water or with the Westphal balance. It is necessary in performing this test that the bubbles of air which tend to adhere to the surface of the asphalt be occasionally removed and that the solution be thoroughly mixed. The usual temperature required for the gravity of this material is 77°F or 25°C.

1E. **Specific Gravity** of solid oil materials.

A fragment of bituminous material is suspended by means of a silk thread from a hook of one pan support of the balance and about ½ inch above the pan and weighed. This weight is "a." It is then immersed in water at 25°C and suspended, the water container not being allowed to touch the balance and is weighed again. This weight is "b." The specific gravity is $\frac{a}{a-b}$ (see lower figure on page 277).

The sample of asphaltic surface mixture for this test should be cut out of the street after the pavement has been rolled and cooled. This test is a very good measure of the all around quality of the work. The sample is weighed in the air and in water, the weight in air divided by the loss of weight in water gives the specific gravity. This times 62.4 gives the weight per cubic foot and times 93.6 gives the weight per square yard of 2-inch surface.

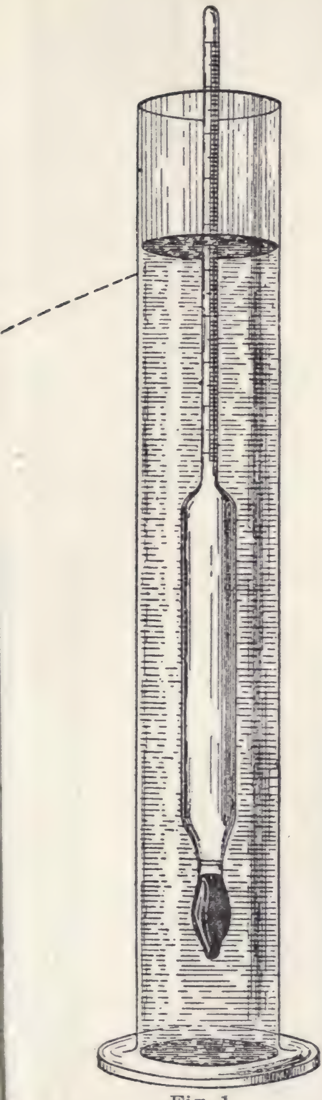


Fig. 1.

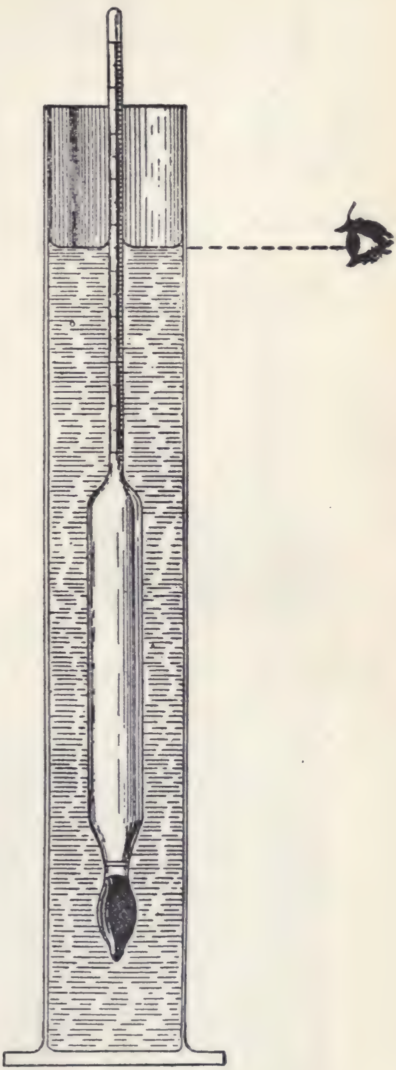
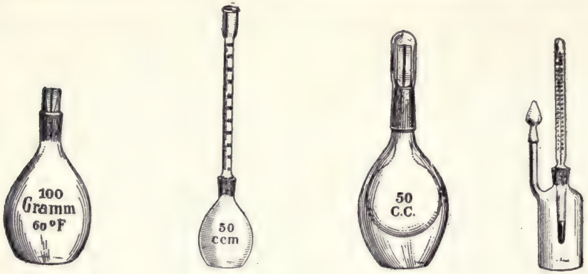
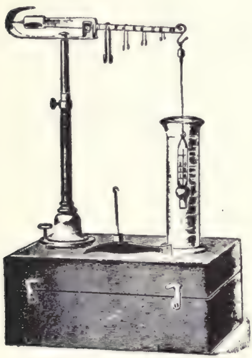
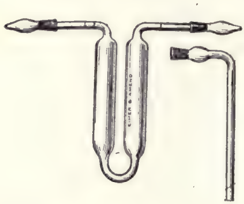


Fig. 2.



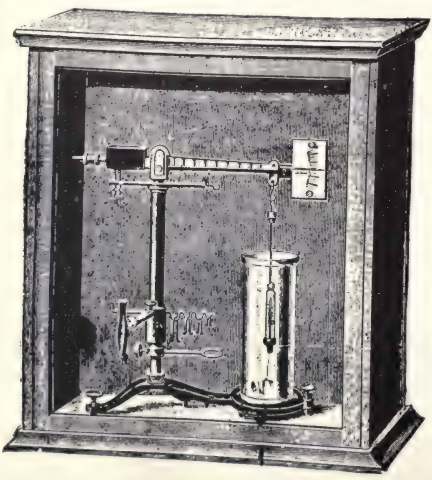

Various types of picnometers

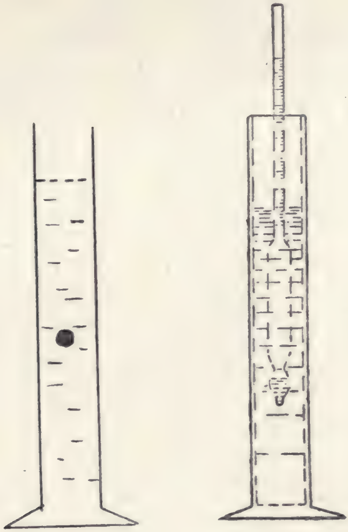




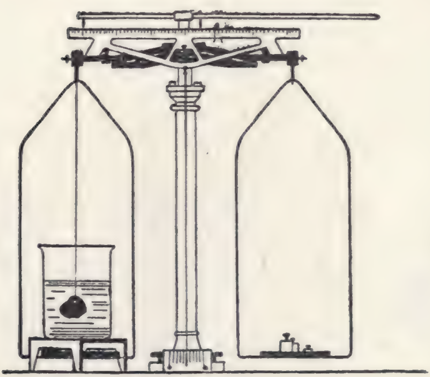
Sprengel
Picnometer

Westphal balance





Specific Gravity of Asphaltic Cement.



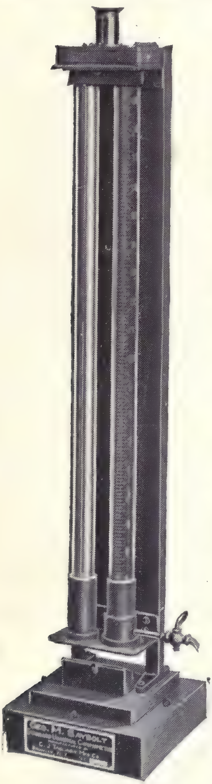
Specific Gravity by Displacement.

## 2A. METHOD FOR DETERMINING THE COLOR OF REFINED PETROLEUM.

(Saybolt Universal Chromometer.)

The apparatus consists of two color comparison tubes, one being arranged for insertion of a standard yellow glass in the bottom, the other being graduated for different lengths of oil column (see figure).

Two like-colored yellow glass discs are supplied with each Chromometer. By the use of one singly or both together, color shades can be definitely determined between below Zero to + 25—Zero being Standard White and + 21 Water White—and as indicated by the accompanying table of inches corresponding to color shades.



Saybolt Chromometer.

The two glasses shall be used to determine color shades up to and including + 15, and only one glass from + 16 to + 25.

An excess of oil above that necessary to equal the working standard in color should be filled into the graduated tube so that in drawing off the excess, the eye can follow the color of oil under examination from dark to lighter, thereby making it easier to detect the point at which the oil and standard coincide.

The apparatus should be set at a window having a one-light sash so that a good light is reflected from the mirror, but not in the direct rays of the sun, and care should be taken that no colored light is reflected toward the instrument from surrounding buildings, tanks or other objects.

To clean the Chromometer before making a new test, simply allow some of the oil to be tested to run through the graduated tube. Even this need not be done between tests of similar oils if the previous oil is well drained through the pet cock, and the tube well filled with the next oil, because the influence of a drop or two of the previous oil remaining can not be seen against the half or nearly full tube of the next oil to be tested.

After using, do not let the instrument stand with the light reflecting up the tubes but move the reflecting mirror out of place, or better yet, put on the cover.

When not in use, always put the color glasses in the pockets prepared for them which will be found on the back of the upright.

For the purpose of most easily determining color shades, the column of oil when nearing the point of coincidence with the standard glass discs, shall be lowered shade by shade by use of the pet cock, until a point is reached where it is questionable as to which is the lighter or darker shade.

Then lower the column of oil one shade more and if the oil column now shows without doubt whiter than the standard glass disc,

the colorating of the oil shall be one shade above this last whiter point, or in other words, at the question point, where it was impossible to detect any difference between the oil and the glass disc.

### TABLE OF COLOR SHADES.

| | Inches of Oil in Tube | Color Shades | |
|---|---|---|---|
| | 20 | 25 | |
| Use One Disc. | 18 | 24 | |
| | 16 | 23 | |
| | 14 | 22 | |
| | 12 | 21 | = water white |
| | 10-6/8 | 20 | |
| | 9-4/8 | 19 | |
| | 8-2/8 | 18 | |
| | 7-2/8 | 17 | |
| | 6-2/8 | 16 | |
| Use Two Discs. | 10-4/8 | +15 | |
| | 9-6/8 | +14 | |
| | 9-0/8 | +13 | |
| | 8-2/8 | +12 | |
| | 7-6/8 | +11 | |
| | 7-2/8 | +10 | |
| | 6-6/8 | + 9 | |
| | 6-4/8 | + 8 | |
| | 6-2/8 | + 7 | |
| | 6-0/8 | + 6 | |
| | 5-6/8 | + 5 | |
| | 5-4/8 | + 4 | |
| | 5-2/8 | + 3 | |
| | 5-0/8 | + 2 | |
| | 4-6/8 | + 1 | |
| | 4-4/8 | 0 | = Standard white |
| | 4-2/8 | — 1 | |
| | 4-0/8 | — 2 | |
| | 3-6/8 | — 3 | |
| | 3-5/8 | — 4 | |
| | 3-4/8 | — 5 | |
| | 3-3/8 | — 6 | |
| | 3-2/8 | — 7 | |
| | 3-1/8 | — 8 | |
| | 3-0/8 | — 9 | |

It is evident that no oils are to be compared with one disc unless they positively show whiter at 10-4/8 inches with two discs.

Moreover, a full tube (20 inches) of white oil that shows whiter than one (1) disc must rate + 25 and up (better than + 25).

### 2-B. COLOR BY LOVIBOND TINTOMETER.

The Lovibond color units and divisions are shown below, together with the color, series and number of each glass. These slides are used for determining the color of the refined products—gasoline, naphtha and kerosene.

Lovibond color unites with specifications for the slides:

| Slide | Color | Series | Number |
|---|---|---|---|
| Water White.... | Yellow | 510 | 2.3 |
| | Red | 200 | 1.6 |
| 1 to 12.0........ | Amber | 500 | 0.1 to 12.0 |

If the oil is darker than the water white glass, slides are added to the slot containing the standard water white until the color of the oil is matched. When the .2 slide is added in this manner, the color is reported as W.W. — 0.2, the minus sign indicating that the oil is darker than the standard water white. If the color of the oil is lighter than that of the water white glass, additional slides are placed in the slots in front of the oil and should the color be matched in this manner with, say the .5 slide and the .2 slide, the color is reported W.W. + 0.70.

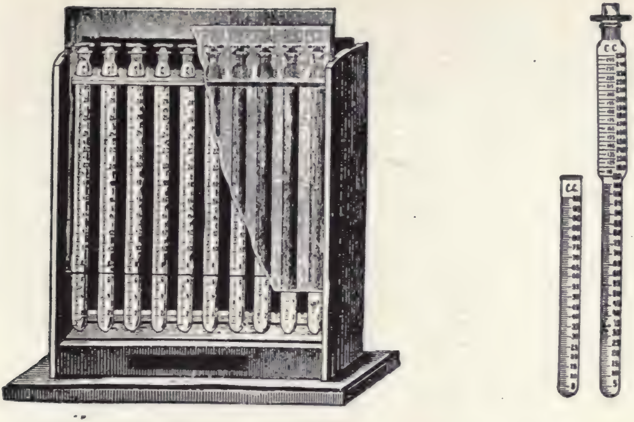
The color equivalent of water white, the standard color for gasoline and naphtha, has been defined as the equivalent of a column 404.6 mm. long of a 0.00027% acidulated solution of potassium chromate. A potassium bichromate solution, however, duplicates the tint of refined petroleum products more closely than the lower oxide. In standardizing the Stammer and Hellige colorimeters, L. Ubbelohde used a solution of 0.06 gram of potassium bichromate in one liter of water as the standard color.

## 2-C. COLOR WITH POTASSIUM BICHROMATE SOLUTIONS.

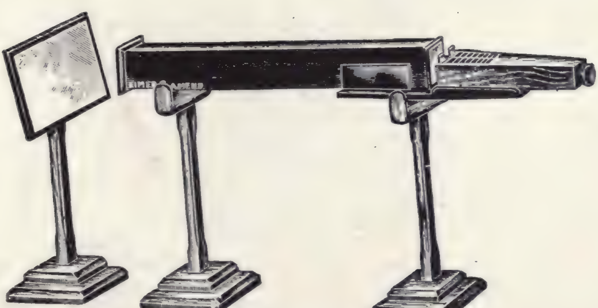
Comparison between Saybolt and Lovibond colorimeter values with equivalent potassium bichromate solutions.

In the absence of an instrument, standard acidulated solutions may be prepared to correspond with the solutions indicated in the following table. Each of these solutions when placed in four-ounce sample bottles and marked with the equivalent Saybolt and Lovibond values may be used to match samples.

| Potassium Bichromate Mgm. per liter of 1% $H_2SO_4$ Solution. | Lovibond Colorimeter 18 cells with W.W. Slide | Saybolt Colorimeter |
|---|---|---|
| 2.0 | W.W. 1 0.5 | 1 25 (light) |
| 2.9 | W.W. | 1 24 (light) |
| 3.8 | W.W. — 0.3 | 1 23 |
| 4.7 | W.W. — 0.5 | 1 22 |
| 5.6 | W.W. — 0.8 | 1 21 |
| 6.5 | W.W. — 1.3 | 1 20 |
| 7.5 | W.W. — 1.5 | 1 19 |
| 8.5 | W.W. — 2.0 | 1 18 |
| 9.5 | W.W. — 2.2 | 1 17 (light) |
| 10.5 | W.W. — 2.8 | 1 16 (light) |
| 11.5 | W.W. — 3.0 | 1 16 |
| 12.5 | W.W. — 3.8 | 1 15 |
| 13.5 | W.W. — 4.5 | 1 14 |
| 14.5 | W.W. — 5.2 | 1 13 |
| 15.5 | W.W. — 5.7 | 1 13 |
| 16.5 | W.W. — 6.0 | 1 12 |
| 17.5 | W.W. — 6.5 | 1 11 |
| 18.6 | W.W. — 6.9 | 1 10 |
| 19.7 | W.W. — 7.4 | 1 9 |
| 20.8 | W.W. — 9.0 | 1 8 |
| 21.9 | W.W. — 9.4 | 1 7 |
| 23.0 | W.W. — 10.0 | 1 6 |
| 24.1 | W.W. — 10.2 | 1 5 |
| 25.3 | W.W. — 11.0 | 1 3 |
| 26.6 | W.W. — 11.0 | 1 3 |
| 28.0 | W.W. — 11.2 | 1 1 (light) |



Color comparison tubes for the determination of the color of petroleum products by the iodine method.



Lovibond Tintometer.

## 2-D. COLOR OF OIL BY IODINE METHOD.

This method may be applied to all dark colored petroleum products. In determining the color by the iodine method a solution is made containing in 1 liter of very pure distilled water, 10 grams of iodine and 20 grams of potassium iodide. This is kept in a glass stoppered bottle. The apparatus necessary is that indicated on page 281 which may be a set of carbon color tubes or two tubes such as are required in the determination of manganese in steel. For crude oil, road oil, fuel oil and other black oils a dilution of 1-1000 in colorless benzol is made by diluting 1 cc. to 10 cc. of benzol and then 1 cc. of this to 100 cc. with benzol. This is thoroughly mixed in one of the glass stoppered color tubes. 1 cc. of the standard iodine solution is put into the large color tube which holds 250 cc. It is diluted with distilled water until its color matches that of the oil under test. The color is calculated, as follows: I = milligrams of iodine in 100 cc. of water in the tube containing the diluted iodine.

d = The number of cc. of benzol to 1 cc. of oil.

Color = I (d + 1).

For gas oil, lubricating oils and yellow oils, a dilution of 1-100 with benzol is sufficient. For gasoline, naphtha, kerosene and illuminating oils there is no dilution with benzol, the comparison being made directly.

The terms applied to the color of crude oil are black, brownish black, blackish brown, brown, reddish brown, green, greenish brown, brownish green and bluish green. The kerosene is spoken of as being water white, superfine white, prime white, standard white, prime light straw, light straw and straw. Other colors are designated by yellow, dark yellow, reddish yellow, brownish yellow, yellowish brown, brown, red, blood red and yellowish red.

## 3. ODOR OF OIL.

The odor of oil may be spoken of as sweet, ethereal, aromatic, tarry, fatty, creosotic, acid, sour, sulphurous, sulphuretted hydrogen, pyridine and pungent.

## 4. TRANSPARENCY OF OILS.

Transparency may be expressed by the thickness of oil in centimeters through which the filament of a 50 watt Mazda electric lamp is visible. It may be also noted whether the oil is fluorescent and the character of the fluorescence, whether bluish, greenish or yellowish by reflected light; also whether any turbidity is of a smoky, granular or flocculent character.

## 5-A. VISCOSITY OF LIQUID PETROLEUM PRODUCTS. (SAYBOLT UNIVERSAL.)

The apparatus is shown on page 285.

This is the tentative test for the viscosity of lubricants adopted by the American Society for Testing Materials:

1. Viscosity shall be determined by means of the Saybolt standard universal viscosimeter.

2. (a) The Saybolt viscosimeter is made entirely of metal. The standard oil tube is fitted at the top with an overflow cup and the tube is surrounded by a bath. At the bottom of the standard oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask, whose capacity to a mark on its neck is 60 (+ 0.15) cc. The lower end of the outlet tube is enclosed by a larger tube, which when stoppered by a cork acts as a closed air chamber and

prevents the flow of oil through the outlet tube until the cork is removed and the test started. A looped string is attached to the lower end of the cork as an aid to its rapid removal. The bath is provided with two stirring paddles and operated by two turn-table handles. The temperatures in the standard oil tube and in the bath are shown by thermometers. The bath may be heated by a gas ring burner, steam U-tube, or electric heater. The standard oil tube is cleaned by means of a tube cleaning plunger, and all oil entering the standard oil tube shall be strained through a 30-mesh brass wire strainer. A stop watch is used for taking the time of flow of the oil and a pipette, fitted with a rubber suction bulb, is used for draining the overflow cup of the standard oil tube.

(b) The standard oil tube should be standardized by the United States Bureau of Standards, Washington, and shall conform to the following dimensions:

| Dimensions. | Minimum, CM. | Normal, CM. | Maximum, CM. |
|---|---|---|---|
| Inside diameter of outlet tube.... | 0.1750 | 0.1765 | 0.1780 |
| Length of outlet tube............ | 1.215 | 1.225 | 1.235 |
| Height of overflow rim above bottom of outlet tube............ | 12.40 | 12.50 | 12.60 |
| Diameter of container of standard oil tube.................... | 2.955 | 2.975 | 2.995 |
| Outer diameter of outlet tube at lower end.................. | 0.28 | 0.30 | 0.32 |

3. Viscosity shall be determined at 100°F (37°.8 C), 130°F (54°.4C), or 210°F (98°.9C). The bath shall be held constant within 0°.25 F (0.14°C) at such a temperature as will maintain the desired temperature in the standard oil tube. For viscosity determinations at 100 and 130°F, oil or water may be used as the bath liquid. For viscosity determinations at 210°F, oil shall be used as the bath liquid. The oil for the bath liquid should be a pale engine oil of at least 350°F flash point (open cup). Viscosity determinations shall be made in a room free from draughts, and from rapid changes in temperature. All oil introduced into the standard oil tube, either for cleaning or for test, shall first be passed through the strainer.

To make the test, heat the oil to the necessary temperature and clean out the standard oil tube with the plunger, using some of the oil to be tested. Place the cork stopper into the lower end of the air chamber at the bottom of the standard oil tube. The stopper should be sufficiently inserted to prevent the escape of air, but should not touch the small outlet tube of the standard oil tube. Heat the oil to be tested, outside the viscosimeter, to slightly below the temperature at which the viscosity is to be determined and pour it into the standard oil tube until it ceases to overflow into the overflow cup.

By means of the oil tube thermometer keep the oil in the standard oil tube well stirred and also stir well the oil in the bath. It is extremely important that the temperature of the oil in the oil bath be maintained constant during the entire time consumed in making the test. When the temperature of the oil in the bath and in the standard oil tube are constant and the oil in the standard oil tube is at the desired temperature, withdraw the oil tube thermometer; quickly remove the surplus oil from the overflow cup by means of a pipette so that the level of the oil in the overflow cup is below the level of the oil in the tube proper; place the 60-cc. flask in position so that the oil

from the outlet tube will flow into the flask without making bubbles; snap the cork from its position, and at the same instant start the stop watch. Stir the liquid in the bath during the run and carefully maintain it at the previously determined proper temperature. Stop the watch when the bottom of the meniscus of the oil reaches the mark on the neck of the receiving flask.

The time in seconds for the delivery of 60-cc. of oil is the Saybolt viscosity of the oil at the temperature at which the test was made. The approximate factors for conversion of readings of the Saybolt Universal to other instruments are as follows:

| | °F 70 | °F 100 | °F 212 | °F 338 |
|---|---|---|---|---|
| To MacMichael | .50 | .55 | .60 | .65 |
| To Saybolt "A" | .50 | 1.00 | .... | .... |
| To Saybolt "C" | .... | .... | .46 | .72 |
| To Engler | .035 | .030 | .028 | .027 |
| To Tagliabue | .25 | .28 | .51 | .... |
| To Penn. R. R. Pipet | .30 | .47 | .51 | .94 |
| To Scott | .13 | .13 | .... | .... |
| To Redwood | .83 | .85 | .88 | .90 |
| To Magruder Plunger | 1.25 | 1.04 | 2.00 | .... |
| To Ostwald | 1.90 | 1.85 | 1.68 | 1.30 |

These values are not exact as they vary greatly with the actual viscosity readings. For exact conversion to Engler and Redwood values, see page 287.

70°F may be used for light oils, gas oils, "straw" oils, engine oils, dynamo oils, auto oils, cottonseed oils and the like.

100°F may be used for Engine oils, machine oils and occasionally cylinder oils.

212°F may be used for cylinder oils, road oil, other heavy oils and asphaltic fluxes.

338°F may be used for asphalt, fluxes, paraffin wax and residues.

Other viscosimeters in use are the Engler, Tagliabue, Scott, Redwood, Penn. Ry. pipet, McMichael, Lamansky-Nobel, Ostwald, Martens, Stormer, Ubbelohde, Lepenau, Kuenkler, Albrecht, Arvine, Barbey, Cockrell, Doolittle, Gibbs, Mason, Napier, Nasmyth, Phillips, Reischauer, Magruder (see page 286).

The Engler viscosimeter is used most extensively in Germany and its dimensions are as follows:

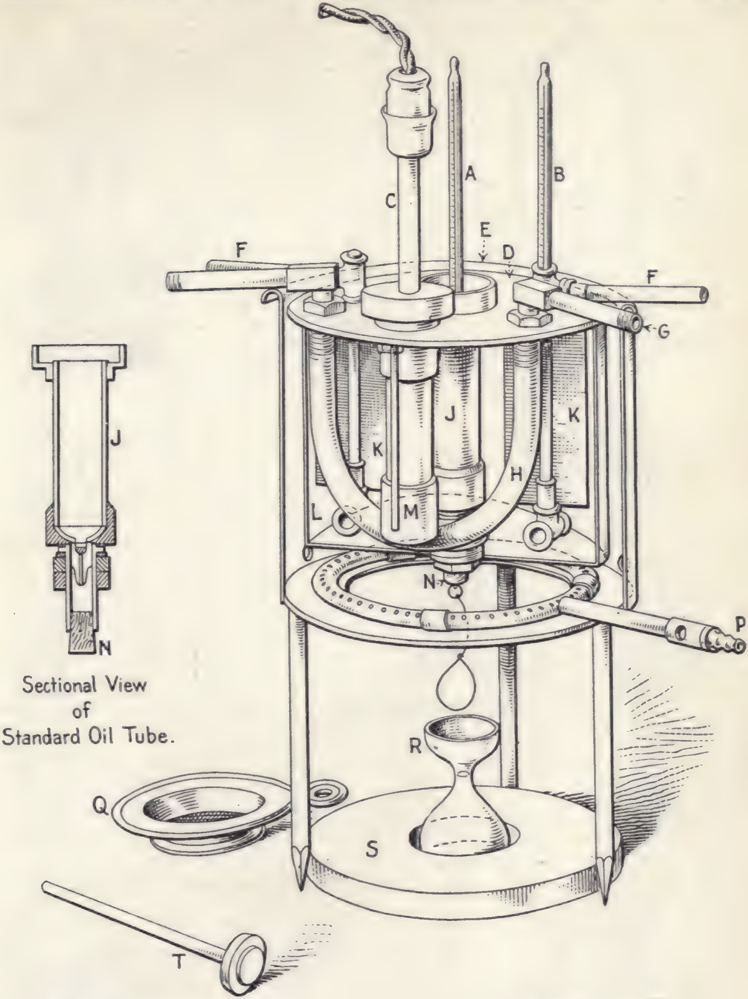
| | |
|---|---|
| Inside diameter of the inside vessel for oil | 106 mm |
| Height of vessel below overflow | 25 mm |
| Length of the oil jet | 20 mm |
| Inside diameter of the oil jet upper end | 2.9 mm |
| Inside diameter of the oil jet lower end | 2.8 mm |
| Length of jet projecting from lower part of outer vessel | 3.0 mm |
| Width of jet | 4.5 mm |

The quotient of the time of outflow of 200 cc. of oil divided by the time of outflow of 200 cc. of water is taken as a measure of the viscosity or is the so-called Engler degree.*

The Redwood viscosimeter‡ is used extensively in England and its value can be calculated from the Engler or the Saybolt in the tables on pages 288-9.

*Holde, Examination of Hydrocarbon Oils.

‡Redwood, Treatise on Petroleum.

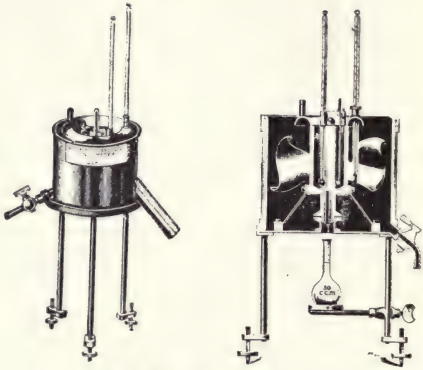



A Oil Tube Thermometer.
B Bath Thermometer.
C Electric Heater.
D Turntable Cover.
E Overflow Cup.
F Turntable Handles.
G Steam Inlet or Outlet
H Steam U–Tube.
J Standard Oil Tube.
K Stirring Paddles.
L Bath Vessel.
M Electric Heater Receptacle.
N Outlet Cork Stopper.
P Gas Burner.
Q Strainer.
R Receiving Flask.
S Base Block.
T Tube Cleaning Plunger.

Sectional View of Saybolt Standard Universal Viscosimeter

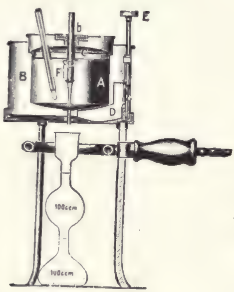
Ostwald

Stormer

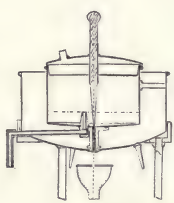


Redwood

Engler

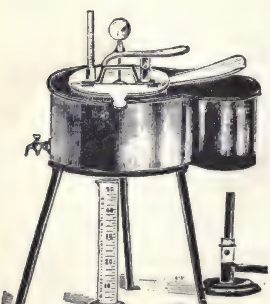


Modified
Engler

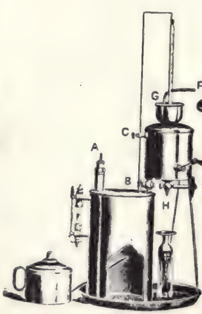


Ubbelohde

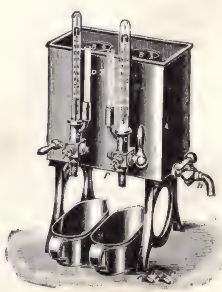
Penn.
R.R.
Pipet



Scott



Tagliabue



Lepenau

VISCOSIMETERS

# Factors to Reduce Saybolt Times to Engler Numbers or to Redwood Times

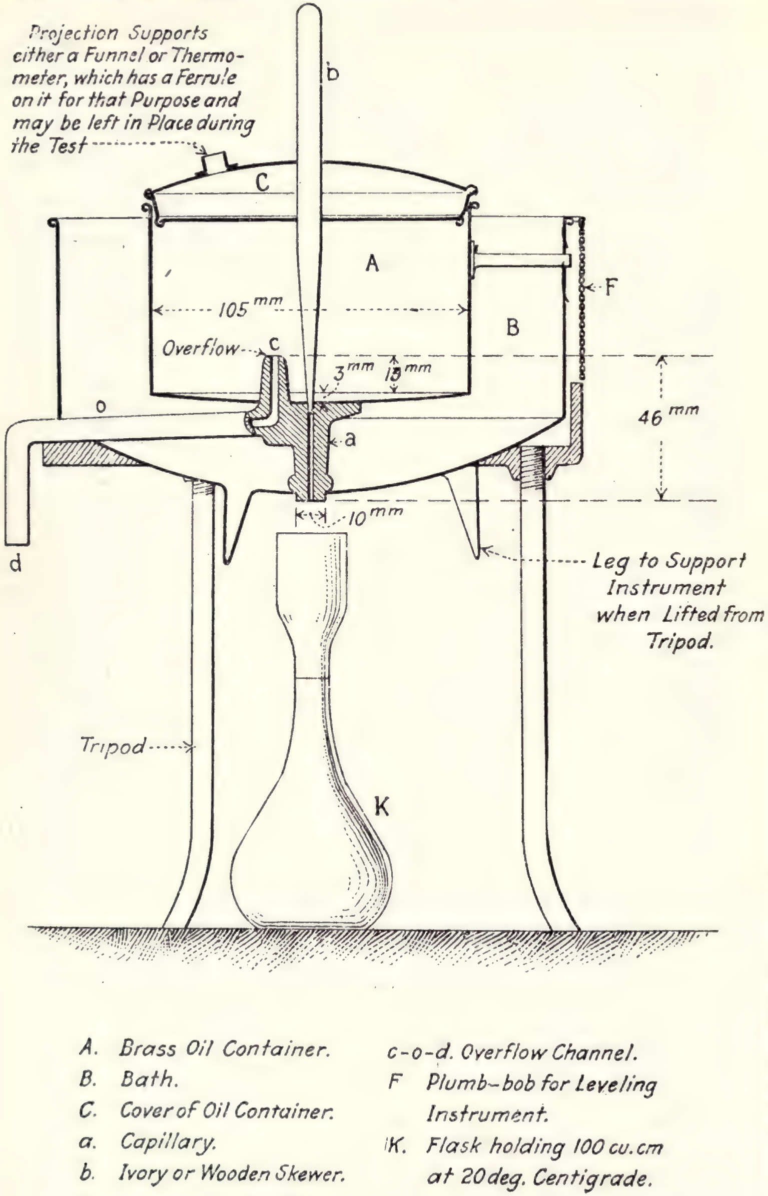
| Saybolt Time, Seconds | Factor to Reduce Saybolt Time to Engler Number | Factor to Reduce Saybolt Time to Redwood Time |
|---|---|---|
| 28 | 0.0357 | 0.95 |
| 30 | 0.0352 | 0.95 |
| 32 | 0.0346 | 0.94 |
| 34 | 0.0342 | 0.94 |
| 36 | 0.0337 | 0.94 |
| 38 | 0.0334 | 0.93 |
| 40 | 0.0330 | 0.93 |
| 42 | 0.0327 | 0.92 |
| 44 | 0.0323 | 0.92 |
| 46 | 0.0320 | 0.91 |
| 48 | 0.0317 | 0.91 |
| 50 | 0.0314 | 0.90 |
| 55 | 0.0308 | 0.90 |
| 60 | 0.0302 | 0.89 |
| 65 | 0.0297 | 0.88 |
| 70 | 0.0293 | 0.87 |
| 75 | 0.0289 | 0.86 |
| 80 | 0.0286 | 0.86 |
| 85 | 0.0284 | 0.86 |
| 90 | 0.0282 | 0.85 |
| 95 | 0.0280 | 0.85 |
| 100 | 0.0297 | 0.85 |
| 110 | 0.0276 | 0.85 |
| 120 | 0.0274 | 0.84 |
| 130 | 0.0272 | 0.84 |
| 140 | 0.0271 | 0.84 |
| 160 | 0.0269 | 0.84 |
| 180 | 0.0268 | 0.84 |
| 200 | 0.0267 | 0.84 |
| ... | ...... | .... |
| 1800 | 0.0267 | 0.84 |

# Factors to Reduce Redwood Times to Saybolt Times or to Engler Numbers

| Redwood Time | Factors to Reduce Redwood Time to Saybolt Time | Factors to Reduce Redwood Time to Engler Number |
|---|---|---|
| 26 | 1.05 | 0.0377 |
| 28 | 1.05 | 0.0372 |
| 30 | 1.06 | 0.0368 |
| 32 | 1.06 | 0.0364 |
| 34 | 1.07 | 0.0361 |
| 36 | 1.07 | 0.0358 |
| 38 | 1.08 | 0.0355 |
| 40 | 1.09 | 0.0353 |
| 42 | 1.10 | 0.0351 |
| 44 | 1.10 | 0.0349 |
| 46 | 1.11 | 0.0347 |
| 48 | 1.12 | 0.0345 |
| 50 | 1.13 | 0.0344 |
| 55 | 1.14 | 0.0340 |
| 60 | 1.15 | 0.0337 |
| 65 | 1.16 | 0.0335 |
| 70 | 1.16 | 0.0333 |
| 75 | 1.17 | 0.0331 |
| 80 | 1.18 | 0.0330 |
| 85 | 1.18 | 0.0329 |
| 90 | 1.18 | 0.0328 |
| 95 | 1.19 | 0.0327 |
| 100 | 1.19 | 0.0326 |
| 110 | 1.19 | 0.0325 |
| 120 | 1.20 | 0.0324 |
| 130 | 1.20 | 0.0322 |
| 140 | 1.20 | 0.0321 |
| 160 | 1.20 | 0.0321 |
| 180 | 1.20 | 0.0320 |
| ... | .... | ...... |
| 1500 | 1.20 | 0.0320 |

# Factors to Reduce Engler Numbers to Saybolt or to Redwood Times

| Engler Number | Factors to Reduce Engler Number to Saybolt Time | Factors to Reduce Engler Number to Redwood Time |
|---|---|---|
| 1.00 | 28.1 | 26.7 |
| 1.05 | 28.4 | 27.0 |
| 1.10 | 28.8 | 27.2 |
| 1.15 | 29.1 | 27.4 |
| 1.20 | 29.5 | 27.6 |
| 1.25 | 29.8 | 27.8 |
| 1.30 | 30.1 | 28.0 |
| 1.35 | 30.4 | 28.2 |
| 1.40 | 30.8 | 28.3 |
| 1.45 | 31.1 | 28.5 |
| 1.50 | 31.5 | 28.6 |
| 1.60 | 32.0 | 28.8 |
| 1.70 | 32.5 | 29.0 |
| 1.80 | 33.0 | 29.2 |
| 1.90 | 33.5 | 29.4 |
| 2.00 | 33.9 | 29.6 |
| 2.10 | 34.2 | 29.7 |
| 2.20 | 34.5 | 29.9 |
| 2.30 | 34.8 | 30.0 |
| 2.40 | 35.1 | 30.1 |
| 2.50 | 35.3 | 30.2 |
| 2.60 | 35.5 | 30.3 |
| 2.70 | 35.7 | 30.3 |
| 2.80 | 35.9 | 30.4 |
| 2.90 | 36.1 | 30.4 |
| 3.00 | 36.2 | 30.5 |
| 3.50 | 36.7 | 30.7 |
| 4.00 | 37.0 | 30.9 |
| 4.50 | 37.3 | 31.1 |
| 5.00 | 37.4 | 31.2 |
| 6.00 | 37.5 | 31.3 |
| .... | .... | .... |
| 50.00 | 37.5 | 31.3 |




The Ubbelohde Viscosimeter.

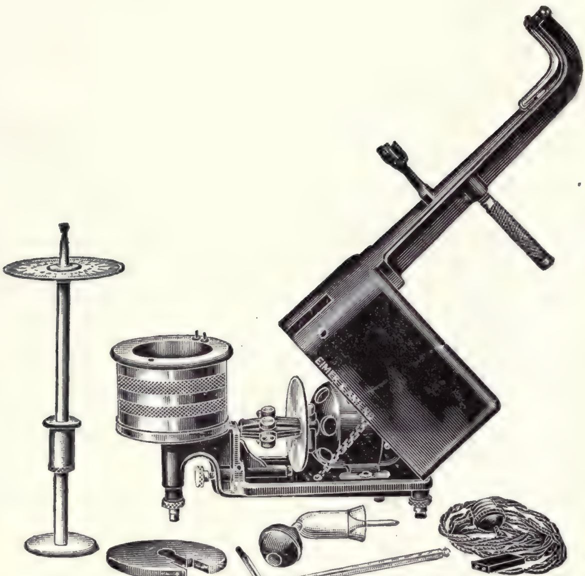
## 5-B. METHOD FOR DETERMINING THE VISCOSITY OF KEROSENE AND GASOLINE.

The apparatus used for this test is essentially that described on pages 55, 56 and 57 of Holde's "Examination of Hydrocarbon Oils." A diagram of the apparatus is shown on page 290. The instrument is known as the Ubbelohde viscosimeter.

The dimensions are as follows:

| | Normal Instrument | |
|---|---|---|
| Inner diameter of outlet tube at top...... | 0.125 | centimeters |
| Inner diameter of outlet tube at bottom.... | 0.125 | " |
| Outside diam. of outlet tube at bottom, $d_1$.. | 1.0 | " |
| Length of outlet tube, 1.................. | 3.0 | " |
| Diameter of container, D................ | 10.5 | " |
| Outside diameter of overflow pipe, $d_2$...... | ... | |
| Initial head on bottom of outlet tube, $h_1$... | 4.6 | " |
| Average head, h (calculated)............ | 3.992 | " |
| Water rate............................. | 200 | seconds |
| Capacity of container.................... | 132 | cubic centimeters |

The apparatus is placed in a horizontal position by means of the plummet F, the outflow tube is examined by looking through from the top with a sheet of white paper underneath to determine if there are any obstructions or dirt. If dirty, the outflow tube is cleaned by drawing a silk thread back and forth through it. Water or cracked ice, depending upon the temperature desired, is placed in the outer vessel B, the plug is put in place and an excess of kerosene or gasoline introduced into A. The excess runs out of the overflow pipe C. The plug b is loosened sufficiently to allow just a drop of liquid to pass out to the jet. When the proper temperature has been maintained for 15 minutes the plug is withdrawn and the time required to fill the 100 cc. flask is determined with the stop watch. This time divided by the time required for water gives the viscosity. For example, if the time of outflow of kerosene is 320 seconds and the water is 200 seconds, the viscosity is 1.6.



The MacMichael Viscosimeter

## 5-C. VISCOSITY WITH THE MacMICHAEL VISCOSIMETER.

In the MacMichael Viscosimeter a disk is suspended in a cup of fluid. The force exerted by the rotation of the fluid on the plunger is measured. This force is equal and opposite to that applied to the cup. Viscosities of oils are quickly and easily obtained at normal temperatures, also at very high and very low temperatures.

The disk is suspended in the cup of fluid by a torsion wire about ten inches long running down through the stem of the plunger and fastened near the bottom. The head of the torsion wire is triangular and is held between two grooved pins at the top of the standard. The cup and plunger may be removed and replaced without manipulating any catches or fastenings. All surfaces are smooth and rounded and may be easily cleaned.

The cup is oil jacketed, being formed of two pieces of heavy spun brass. Within the oil jacket is immersed an electric heating coil. This coil draws current from the same line as the motor, only one connection being necessary. The fluid to be tested is heated in place, no other heating device being required. The operation is very rapid. Stirring is effected by a slight vertical movement of the plunger. For low temperature work, the fluid and the adjacent parts are chilled in an ice bath or brine solution.

A bent thermometer inserted through an opening in the cover indicates the temperature, the bulb being immersed in the liquid. The temperature during test may be controlled to within a small fraction of one degree.

The graduated dial at the top of the plunger is secured to the stem by a friction disk, permitting the adjustment of the zero mark to its proper location. The fine adjustment is effected by means of the steel wire pointer at the head of the standard. The dash pot on the stem of the plunger is frictionless and automatic in action, requiring no attention from the operator. Its function is to check incipient vibrations and to permit quicker readings by damping the action.

The speed control is of the phonograph type and gives excellent results. The motor is furnished for 110 or 220 volts either A. C. or D. C. and is adapted for ordinary lighting circuits. Variations in voltage do not affect the accuracy of the determinations.

In operating, the cup is filled to the mark on the side with the oil or asphalt to be tested. This requires about 100 cc. The temperature is raised or lowered by means of the heating coils. The deflection noted on the dial is the viscosity of the fluid.

The operation is very rapid, so that the drop in temperature on ordinary work is entirely negligible. For extreme accuracy, the temperature may be raised slightly above the desired point, and an allowance made for the drop up to the moment of reading. This will seldom be found necessary in actual practice. The readings are in degrees of angular deflection, 300° to the circle, designated as °M. The practical working unit is 1/1000 of the absolute unit. As water at 20°C or 68°F has exactly 1/100 of the absolute unit of viscosity, water at this temperature reads 10°M. Thus by shifting the decimal point practical units, absolute units and specific viscosity may be obtained at one reading. Readings are taken directly from the dial, no intermediate calculations being required.

## 5-D. FLOAT TEST (VISCOSITY) OF PETROLEUM RESIDUES.

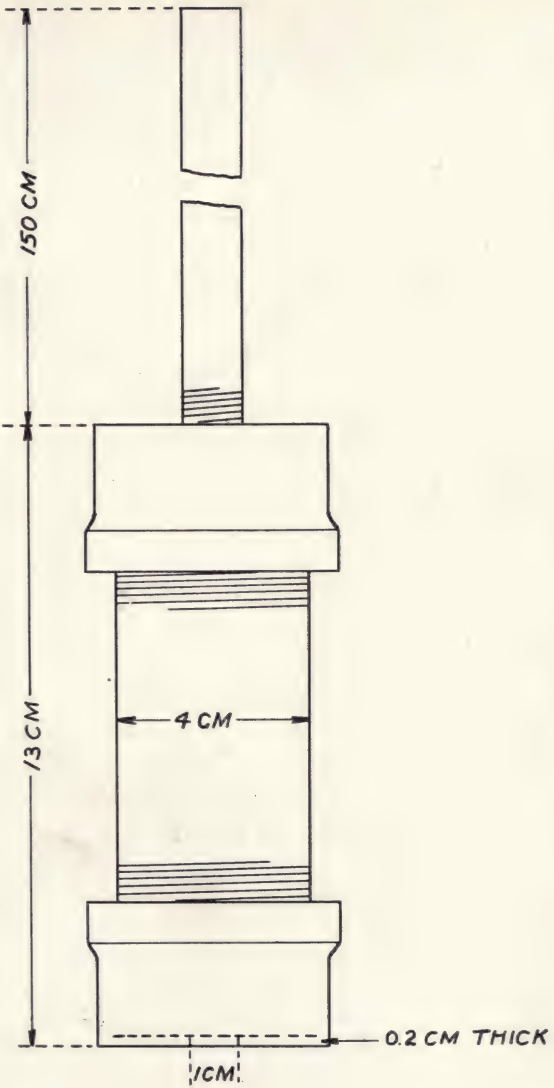
The special apparatus for the float test consists of an aluminum saucer having a diameter of 8.89 centimeters and a depth of 2.54 cm. and a radius of curvature of 5.16 cm. At the bottom there is an opening into which a collar may be screwed. This conical collar is 2.22 cm. long, is 0.95 cm. in diameter at the small end, 1.27 cm. in diameter at the large end and has a wall 0.13 cm. thick. This apparatus and method of operating is shown in the figures on page 296

In making the test the brass conical collar is placed with the small end down on a brass plate which has been previously amalgamated with mercuric chloride. A small quantity of the material to be tested is carefully heated until quite fluid. It is then poured into the collar until slightly more than level with the top. The collar and plate are placed in ice water until rigid. The excess of material protruding from the collar is cut off with a warm knife. A pan of water is now heated to the desired temperature. The material should be kept in the ice water at least 15 minutes at a temperature of 5°C. The collar with the material is quickly screwed into the aluminum float which is immediately placed in the warm bath. As the plug of material becomes warm and fluid it is forced upward and out of the collar until the water gains entrance to the saucer and causes it to sink. The time in seconds between placing the apparatus on the water and when the water breaks through the residue is determined with the stop watch and is recorded as the measure of the consistency of the material. Unless otherwise specified, the float test is made at 50°C, but it would necessarily be higher with the more viscous materials.

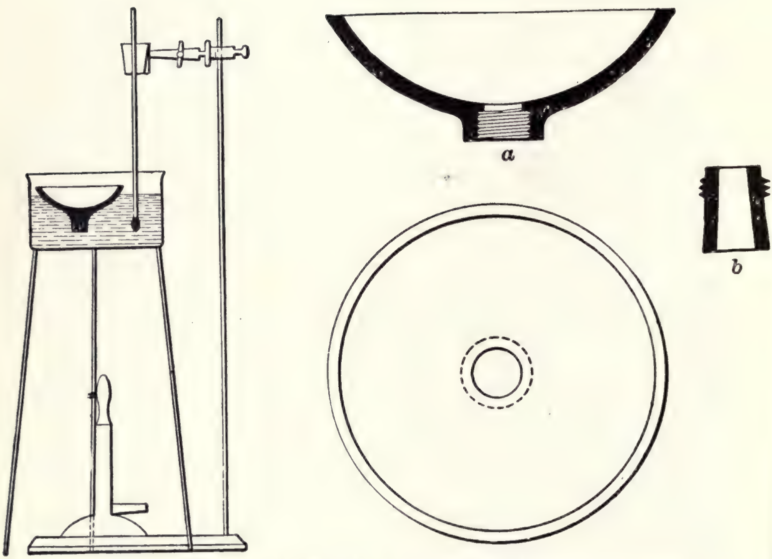
## 5-E. ZERO VISCOSITY FOR SEMI-SOLID PETROLEUM PRODUCTS.

The apparatus used is a cylinder as shown in the sketch and may be constructed from ordinary iron pipe. The cylinder is 4 cm. in diameter and 13 cm. long with an opening centrally located in the bottom 1 cm. in diameter and with lips 2 mm. thick. A tube 150 cm. long is screwed into the cap on the top.

In making the test the melted asphalt is poured into the cylinder with the cap off of the top and the 1 cm. opening on the flat surface. It is cooled and topped with more asphalt, the cap is put on with 150 cm. tube and the cylinder is packed in pulverized ice and supported horizontally so that the bottom rests on a circular ring at least 1 cm. high which keeps the ice away from the orifice. The tube is filled with mercury and after some of the asphalt has protruded from the orifice it is trimmed off flush with the outer edge. The apparatus is now supported vertically at the temperature of 0°C for 5 hours. The weight of asphalt or bituminous material protruding from the orifice after this time expressed in decigrams is the zero viscosity.




ZERO VISCOSITY




New York Testing Laboratory Float Apparatus

### 6-A. MELTING POINT OF BITUMINOUS MATERIALS. (SOFTENING POINT.) (Ring and Ball Method.)

The apparatus consists of a brass ring ⅝-inch in diameter, ¼-inch deep, 3/32-inch wall suspended 1 inch above the bottom of the beaker; a steel ball ⅜-inch in diameter weighing between 3.45 and 3.50 grams, a standardized thermometer and a 600 cc. glass beaker.

Carefully melt the sample and fill the ring with the material to be tested, removing any excess. Place the ball in the center of the ring and suspend in the beaker containing 400 cc. of water at a temperature of 5°C. Set the thermometer bulb within ½ inch of the sample and at the same level. Apply heat uniformly, preferably with a 200 watt electric hot plate over the bottom of the beaker sufficiently to raise the temperature of the water 5°C per minute. Record the temperature at starting the test and every minute thereafter until the test is completed. The softening point is the temperature at which the specimen touches the bottom of the beaker. For temperatures above 99°C glycerin should be used instead of water. Tests should check within 3°C.

### 6-B. MELTING POINT OF BITUMINOUS MATERIALS. (Cube Method.)

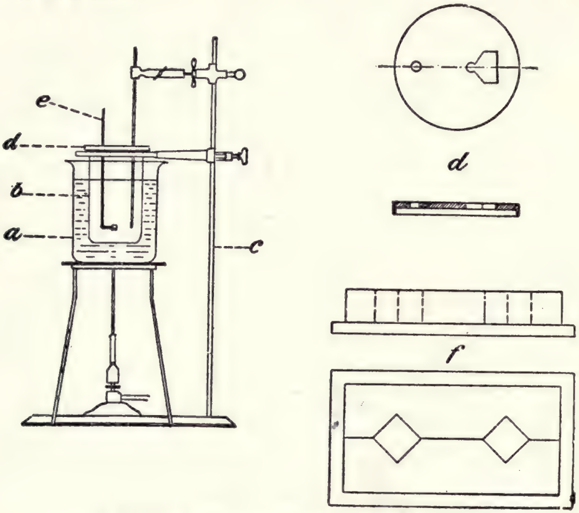
The bituminous material is carefully melted and poured into the ½-inch brass cubical mold which has been amalgamated with mercury and which is set on an amalgamated brass plate. The hot material should slightly more than fill the mold and when cold the excess may be cut off with a hot spatula. The cube is removed from the mold and fastened upon the lower arm of a No. 12 wire B. & S. gauge bent at right angles and suspended beside a thermometer in a tall covered beaker of 400 cc. capacity.

This tall form beaker is set in an 800 cc. low form beaker which is arranged for the application of heat. The wire is passed through the center of the two opposite faces of the cube which is suspended with its base one inch above the bottom of the inside beaker. The inner beaker cover has two openings, one for the wire and one for the thermometer. The wire is held in place by a cork in the cover. The bulb of the thermometer is level with the cube and at an equal distance from the sides of the beaker. Heat is applied to the liquid in the outer vessel in such manner that the thermometer registers an increase of 5°C per minute and the temperature at which the bitumen touches a piece of paper placed in the bottom of the beaker is taken as the melting point. Determinations should check within 2°. The temperature at the beginning of the test should be approximately room temperature.

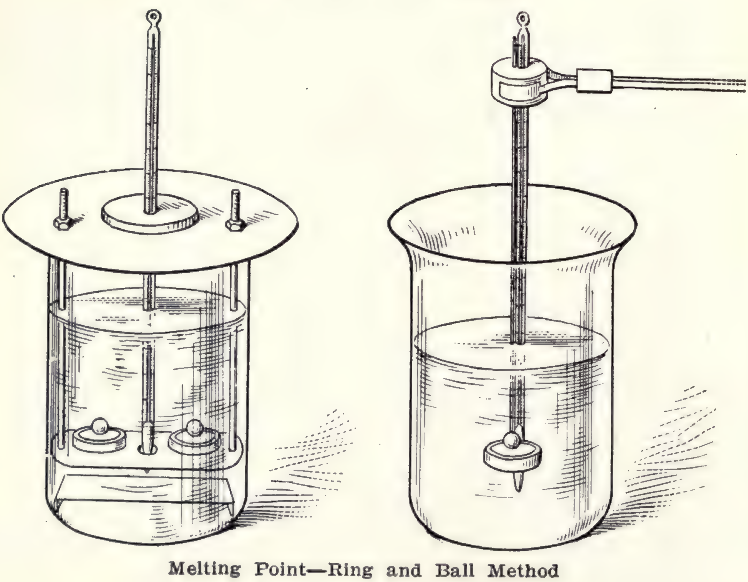
### 6-C. MELTING POINT OF BITUMINOUS MATERIALS. (General Electric Method.)

Mold one gram of the bituminous material so that it completely and uniformly covers the short bulb of a thermometer graduated to at least 500°F. Fit this thermometer with a cork into a ⅝ x 6-inch test tube with a side tubulation or air vent so that the bulb of the thermometer is ¾-inch from the bottom of the tube. Support the thermometer and tube with a clamp and immerse the tube to a depth of four inches in 400 cc. of commercial concentrated sulphuric acid in a 600 cc. beaker. The beaker of sulphuric acid is heated by direct contact with an electric hot plate of 220 watt capacity and 4½ inches in diameter.

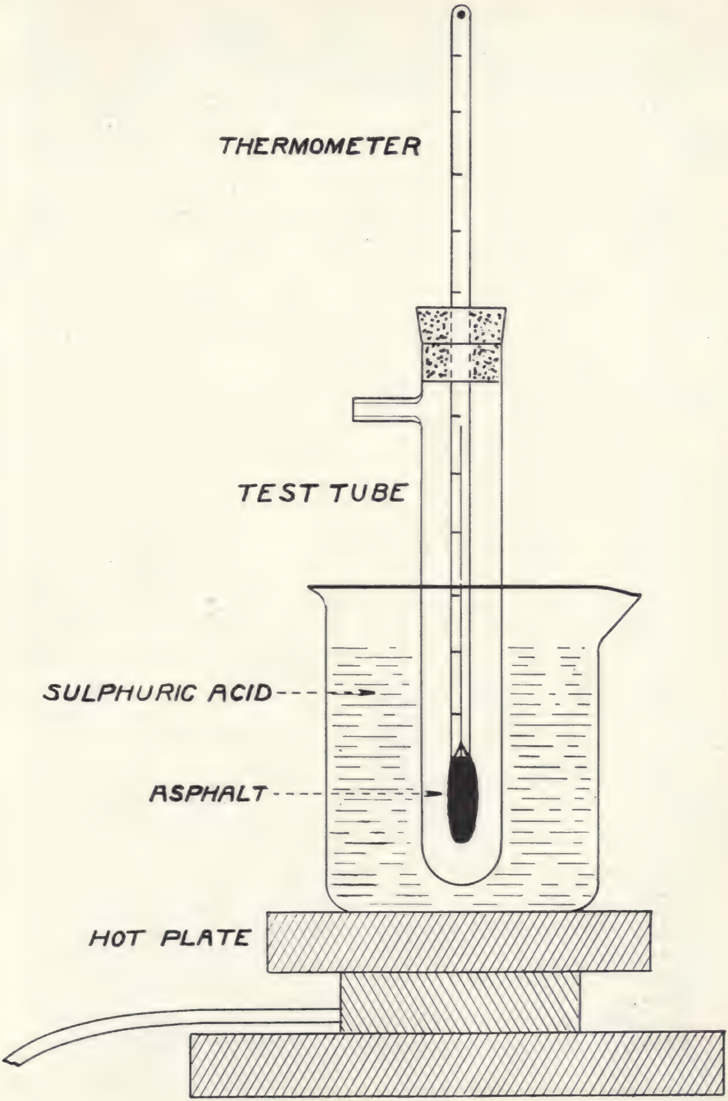
The melting point is taken from readings of the thermometer when the bituminous material flows sufficiently that a tear strikes the bottom of the tube.



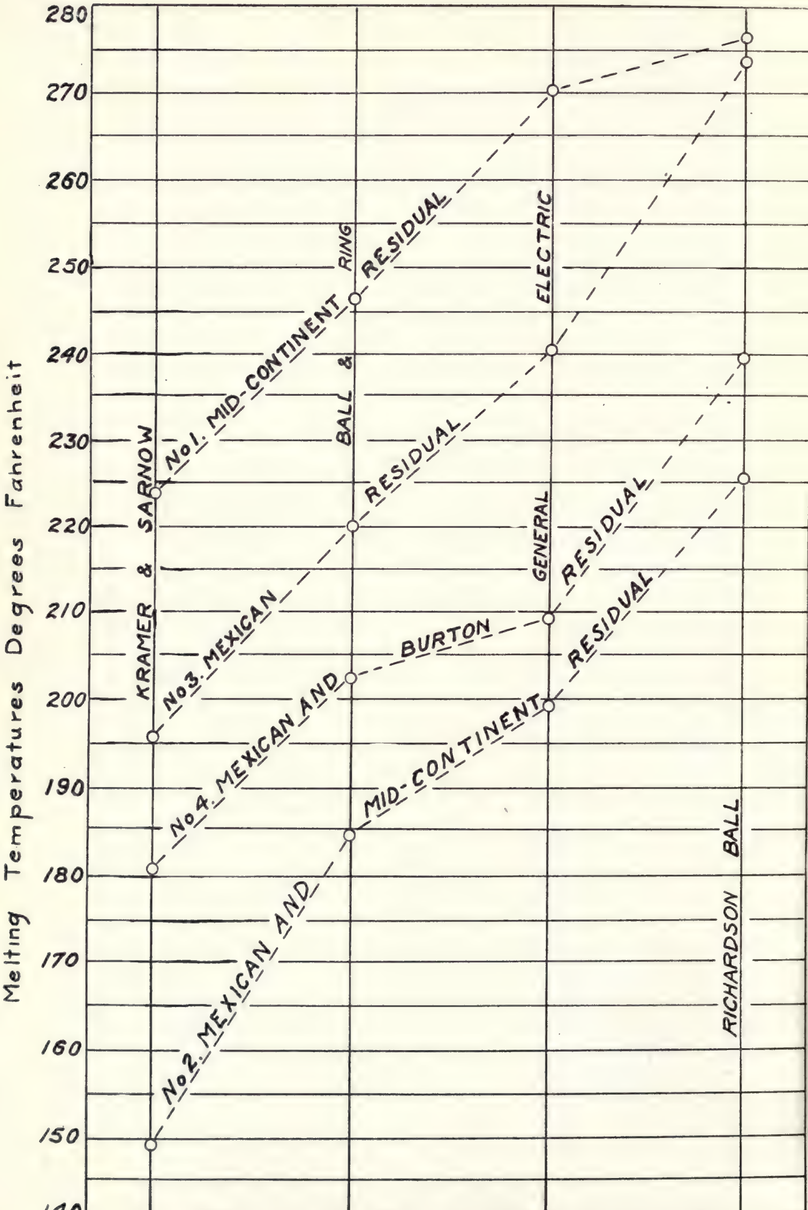

Melting Point—Cube Method



Melting Point—Ring and Ball Method




MELTING POINT - G.E. METHOD.




COMPARISON OF MELTING POINT DETERMINATIONS.

### 6-D. METHOD OF DETERMINING THE MELTING POINT OF PARAFFIN WAX.

Use the apparatus consisting of a 1x8 inch test tube fitted into a bottle all as shown on page 302.

Pour the melted paraffin into the test tube to a depth of three inches and insert a special wax or titer test thermometer graduated to .1°F. Place it exactly in the center of the tube so that the bottom of the thermometer is one-half inch from the bottom of the test tube. Let the apparatus stand in a warm place preferably in a blood temperature incubator or at 100°F and take readings of the thermometer every minute.

Continue the readings until the wax is nearly solid.

The melting point is the average of the three one-minute readings which are most nearly identical. In the case of high melting point wax these readings are practically identical. In the case of low melting point wax there would be some difference in the readings.

This method is graphically illustrated on page 303.

Note.—See Scientific Paper No. 340 of U. S. Bureau of Standards, Sept. 12, 1919.

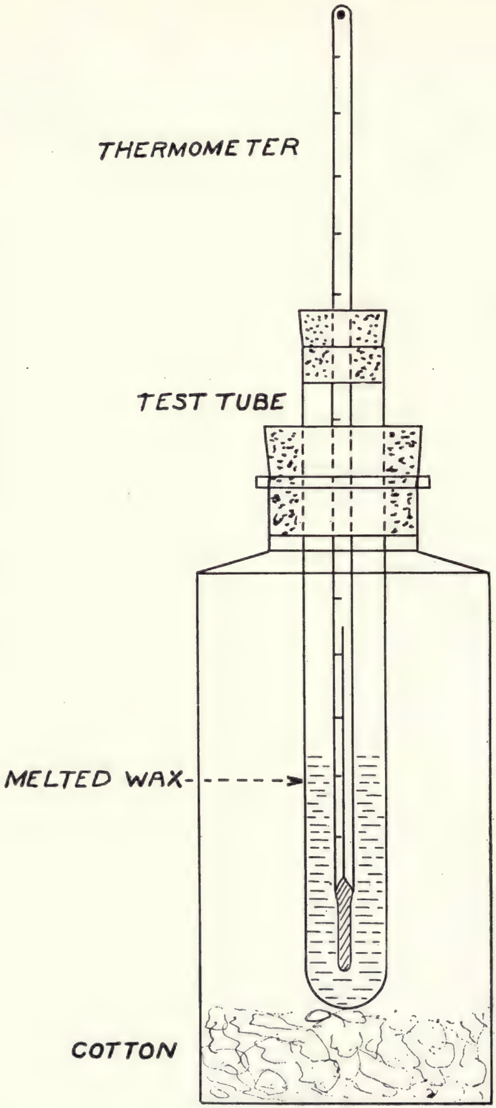
### 7-A. CLOUD, POUR AND COLD TESTS OF PETROLEUM OILS.

Put the oil to be tested in a glass jar or bottle approximately 1¼ inches inside diameter and 5 inches high, to a height of about 1¼ inches or sufficient to reach ¼-inch above the mercury bulb of the thermometer. The thermometer should have a bulb about ⅜-inch long and is held centrally in the jar with a tightly fitting cork and with the lower end of the bulb ½-inch from the bottom of the jar.

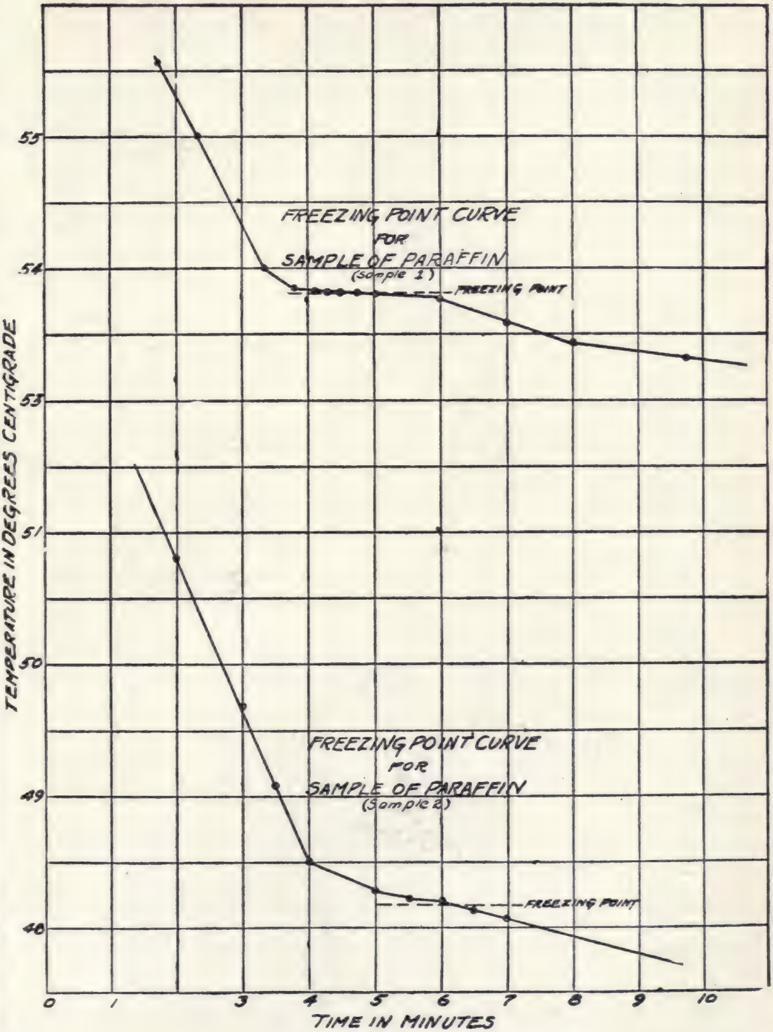
Now place the cold test bottle in a metal or glass jacket about 5 inches high having a diameter about ½-inch greater than the outside diameter of the bottle. A disc of cork ¼-inch in thickness is placed in the bottom of the jar. Put the apparatus in the refrigerating mixture and place the bottle so that it does not touch the jacket. At every drop in temperature of 2°F when near the expected cloud test, remove the jar from the jacket, being careful not to disturb the oil by moving the thermometer. When the lower half of the sample becomes opaque through chilling, read the thermometer. This temperature is the cloud test of the oil.

7-B. For the **POUR TEST** (usually called Cold Test) continue the cloud test, and at each drop in temperature of 5°F remove the bottle from the jacket and tilt it until the oil begins to flow. When the oil has become solid around the thermometer and will not flow, the previous 5° point shall be taken as the pour test. For oil solidifying above 35°F pounded ice may be used for the refrigerating mixture. For temperatures below this and down to —5°F a mixture of 2 parts of pulverized ice and 1 part of salt may be used. From —5°F and to —25°F a mixture of equal parts of pulverized ice and calcium chloride may be used. A universal frozen mixture for all these temperatures can be made as follows:

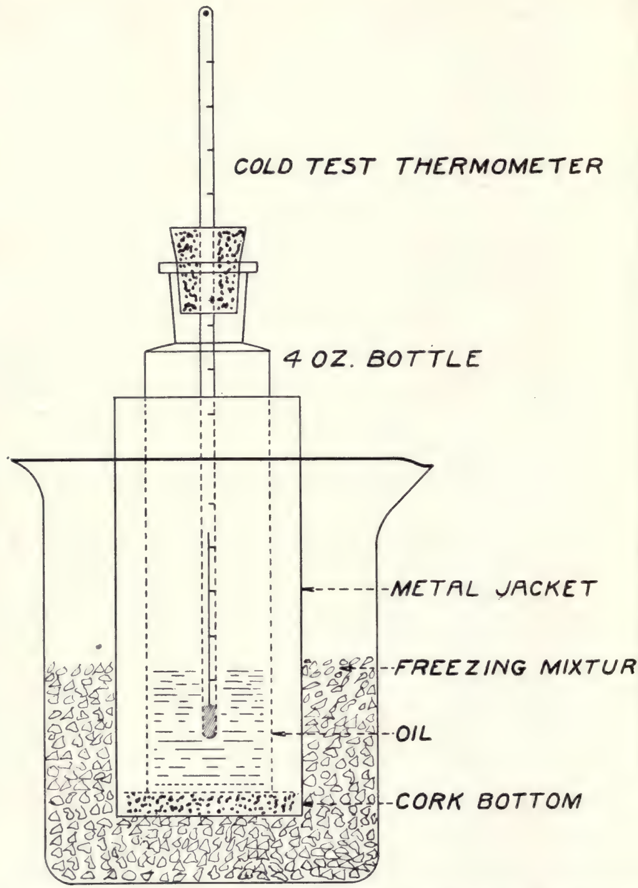
Put a sufficient amount of dry acetone into a covered metal beaker. Put the beaker into an ice salt mixture and when the temperature of the acetone reaches 10°F or below, slowly add carbon dioxide snow until the desired temperature is reached. A temperature as low as —70°F can be thus attained. To get the solid carbon dioxide snow invert an ordinary carbon dioxide cylinder. Open the valve slowly and let the liquid run out into a close mesh bag. By rapid evaporation the carbon dioxide becomes solid. (Continued p. 304.)




MELTING POINT OF PARAFFIN WAX




*Solidification curves for paraffin*




APPARATUS FOR CLOUD TEST, POUR TEST, COLD TEST.

7-C. **COLD TEST** specially for steam cylinder and black oils.

The same bottle used in the pour and cloud tests is filled ¼ full and frozen with a freezing mixture. A thermometer is then introduced into the frozen mass and after it has become cold the bottle containing the solidified oil is removed from the cooling mixture. The solidified oil is thoroughly stirred with the thermometer until the

mass will run from one end of the bottle to the other and at this moment the temperature indicated is recorded. This reading is the cold test of the oil.

### 8-A. SEDIMENT, WATER, DIRT AND BOTTOM SETTLINGS IN PETROLEUM.

(Apparatus is shown on page 337.)

50 cc. of the oil are thoroughly mixed with 50 cc. of benzol and the mixture is poured into a 100 cc. graduated V-shaped centrifuge tube such as is shown on page 337. This is exactly counter-balanced and run in the electric centrifuge at a speed of approximately 2,000 R. P. M. for 5 minutes or until there is a sharp line of demarkation between the sediment or dirt, the water and the oil, if any water or dirt are present. The amount of sediment or dirt is read off by volume and expressed in percentage by volume. The water is also expressed in percentage by volume.

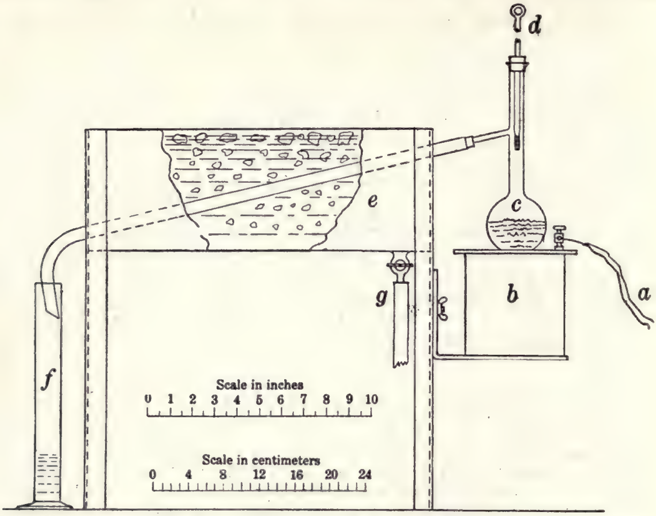
### 8-B. WATER BY DISTILLATION OF PETROLEUM.

100 cc. of the oil are placed in a flask connected to a distillation apparatus as shown on page 308. This is heated until foaming starts when an auxiliary flame is applied to all parts of the upper portion of the flask causing any water vapor to pass over into the condenser without allowing water to collect in the neck of the flask. This heating also tends to prevent the extension of the foam into the condenser. The flame beneath the flask must be applied very gently. This is continued until all foaming ceases and all water has been distilled over from the condenser. The number of cubic centimeters of water collected in the receiver is the percentage of water.

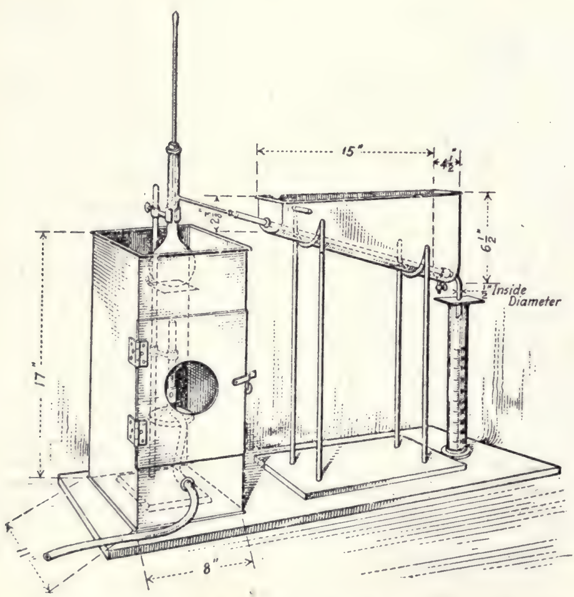
### 9-A. PROXIMATE DISTILLATION OF PETROLEUM.

400 cc. of the petroleum are poured into a 1,000 cc. flask which is connected to a condenser (as shown on page 310). The thermometer is inserted so that the top of the bulb is just below the outlet of the flask. The flame is gradually applied to the oil so that any foaming will tend to make itself evident. If there is foaming it will be necessary to heat the upper portion of the flask. Before the application of the flame to prevent foaming, it is necessary to get the temperature at which the first drop falls into the receiver. This is the initial boiling point. The distillate is collected until a temperature of 410°F is reached when distillation is proceeding at the rate of 5 cc. per minute. The fraction collected up to this temperature is the gasoline or naphtha, the gravity of which is determined. If the gravity is less than 57, it is classified as naphtha, if above this, it is classified as gasoline. The distillation is continued at the same rate until a temperature of 572°F is reached. This fraction is kerosene and its gravity is determined. The residue in the flask is fuel oil and is used for the determination of wax or asphalt, gas oil or lubricants. The information given by this distillation is:

| | | | |
|---|---|---|---|
| Water | | | ———% |
| Gasoline | (———410°F) | (Gr. = ——— = ———Be°) | ———% |
| Kerosene | (410 —572°F) | (Gr. = ——— = ———Be°) | ———% |
| Fuel Oil—Residuum | | (Gr. = ——— = ———Be°) | ———% |
| | | | 100.0% |




—Apparatus used by the Bureau of Mines for distillation test of gasoline. *a* Wires connecting with electric mains through a suitable rheostat. *b* Electric heater. *c* Engler distillation flask filled with charge of gasoline partly distilled. *d* Thermometer. *e* Condenser, with trough filled with ice and water. *f* Receiving graduate. *g* Cock for draining condenser trough.




American Society for Testing Materials Apparatus.

## 9B. END POINT DISTILLATION TEST OF GASOLINE, NAPHTHA AND BENZINE.

This method is essentially that of the American Society for Testing Materials, page 606 of 1918 Book of Standards, and is the method given by the Bureau of Mines in Technical Paper 166 with slight modifications.

The apparatus used in the distillation is as follows: The flask used shall be the standard 100 cc. Engler flask. The dimensions are as follows:

| | Cm. | Inches |
|---|---|---|
| Diameter of bulb | 6.5 | 2.56 |
| Diameter of neck | 1.6 | 0.63 |
| Length of neck | 15.0 | 5.91 |
| Length of water tube | 10.0 | 3.94 |
| Diameter of vapor tube | 0.6 | 0.24 |

Position of vapor tube 9 cm. (3.55 in.) above surface of oil when flask contains its charge of 100 cc. The tube is approximately in the middle of the neck.

The flask shall be supported on a ring of asbestos having a circular opening 1¼ in. in diameter; this means that only this limited portion of the flask is to be heated. The use of a sand bath is not approved.

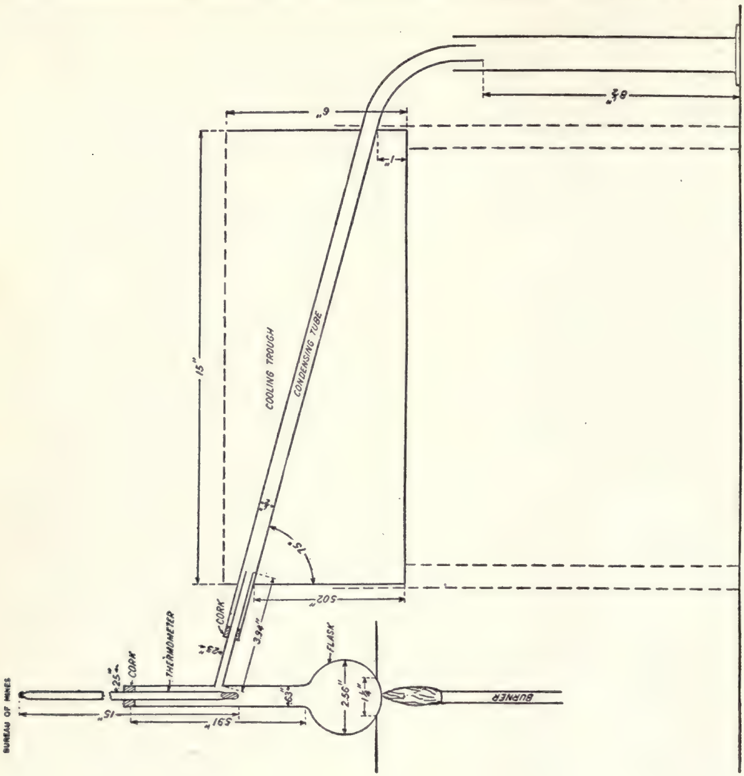
The condenser tube shall consist of a thin walled tube of metal (brass or copper) ½ inch internal diameter and 22 inches long. It shall be set at an angle of 75° from the perpendicular and shall be surrounded with a water jacket of the trough type. The lower end of the condenser shall be cut off at an acute angle and shall be curved down for a length of 3 inches. The condenser jacket shall be 15 inches long.

Briefly the thermometer should be an accurate "nitrogen-filled" instrument with a short bulb (length 10 to 15 mm. 0.39 to 0.59 inch) and with the mark for 35°C (95°F) at a distance between 100 and 120 mm. (3.94 to 4.73 inches) from the top of the bulb. The thermometer should be scaled for total immersion.

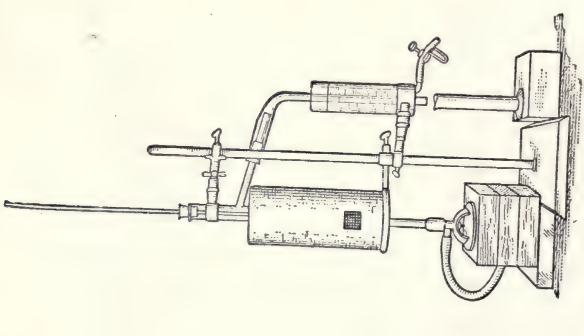
The above requirements insure that the lowest temperatures registered may be read above the cork of the distillation flask and variations because of the so-called "stem correction" will always be practically the same. The stem correction should not be applied but it should be understood that the results of distillations are expressed in terms of thermometer readings, not of actual temperatures. The use of partial-immersion thermometers is not recommended for distillations as these instruments are no more likely to agree with one another than are the more common total immersion thermometers.

### Method of Distillation.

Pour some of the gasoline or naphtha to be tested through the condenser tube just before the distillation flask is connected with it and allow it to drain before placing the receiver. Likewise the distillation flask is rinsed out with the gasoline or naphtha to be distilled and drained before the charge of 100 cc. is added to it. The 100 cc. graduated cylinder may be used without drying as the receiving vessel for the distillation.




APPARATUS FOR DISTILLATION TESTS OF GASOLINE.



Water in Crude Oil

The thermometer bulb should be covered with a thin film of absorbent cotton. This keeps the glass always wet with the condensate from the vapor and thus prevents possible fluctuations in the temperature. It also tends to prevent superheating of the bulb at the end of the distillation and thus makes possible an accurate determination of the dry point.

Heat should be applied to the flask in regulated degree, care being taken that the whole distillation from beginning to end shall proceed at a rate of not less than 4 nor more than 5 cc. a minute (about 2 to 3 drops per second). Readings of the thermometer shall be made as each 5% distills. The temperature at which the first drop falls from the exit of the condenser tube is the initial boiling point.

The dry point, end point or highest temperature reading at the end of the distillation shall also be recorded. It is the temperature when the last drop is vaporized and a puff of white vapor appears in the flask. The distillation loss shall be determined by adding the percentage of residue in the distilling flask, after cooling, to the percentage of total distillates held in the receiver. If the distillation loss is over 3%, a check distillation shall be made, as excessive loss may indicate that the rate of distillation at the beginning was too rapid. In case the magnitude of the loss is confirmed this fact is of importance in indicating that the gasoline contains very volatile constituents, particularly those derived from added casinghead gasoline.

The condenser trough shall be filled with a mixture of finely cracked ice and water (not dry cracked ice) and during the distillation sufficient ice shall be kept in the trough to prevent the temperature of the cooling water exceeding 4°C (39°F).

If distillations are made at high altitudes or when barometric pressures are low, allowances may be made for this factor. In general, recording the barometric pressure read at the time of the distillation will suffice and it is recommended that whenever there is possibility of dispute over the results of a distillation this should be done.

In finishing the distillation there is always a small amount of naphtha remaining in the flask in the vapor phase in excess of that required to wet the inside of the flask. If the residue in the flask has not been poured into the receiver the end point of 98% is to be read as 100% and any loss is to be calculated as the difference between the 98% and the amount actually recovered after the condenser tube has thoroughly drained.

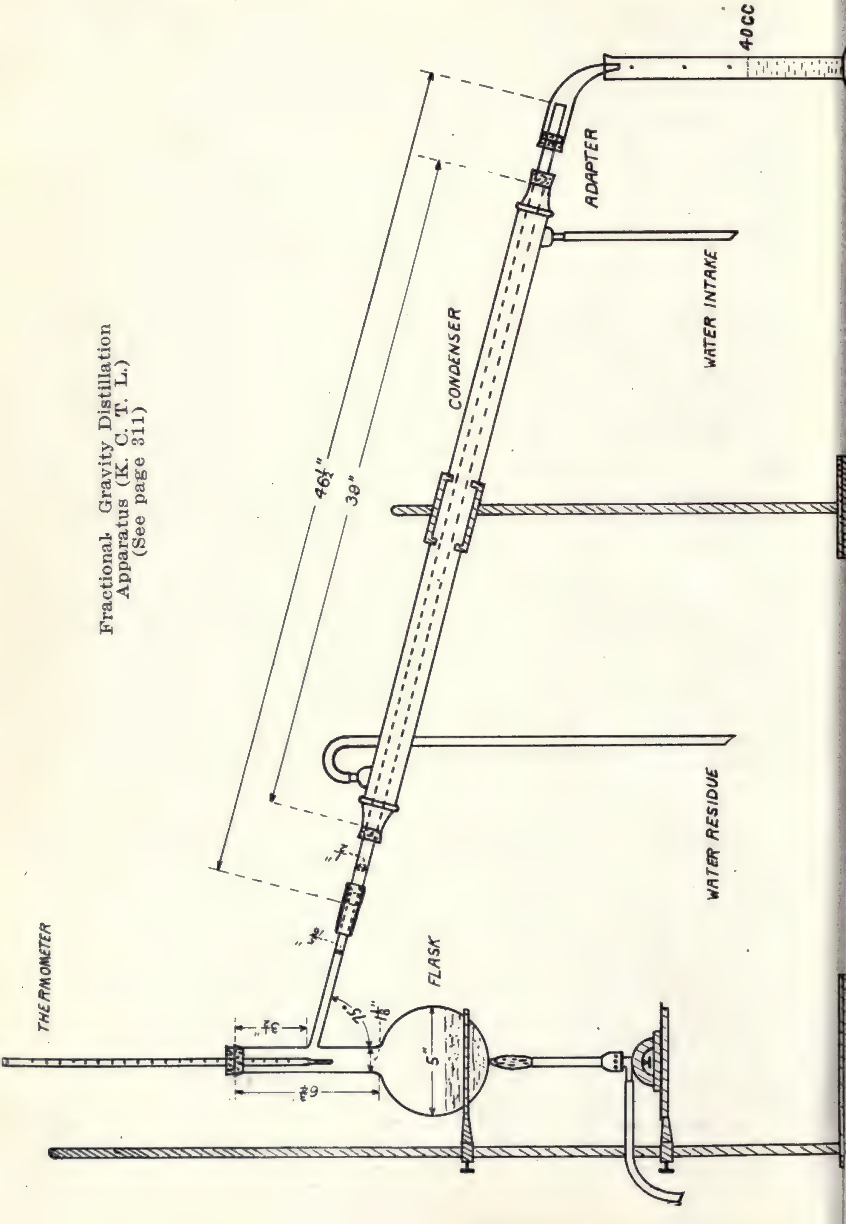
This method is identical with that of the Bureau of Mines with the following exceptions:

Five cc. readings instead of 10 cc. are made.

The condenser is kept at 4°C or below (B. of M. is below 8°C).

The condenser tube and flask are moistened with the gasoline or naphtha to be distilled.

The preceding page shows a cut of the apparatus for distillation. The A. S. T. M. apparatus and the electrically heated apparatus of the Bureau of Mines are shown on page 306.




Fractional Gravity Distillation Apparatus (K. C. T. L.)
(See page 311)

## 9C. FRACTIONAL GRAVITY DISTILLATION OF PETROLEUM.

Use a 1,000 cc. distilling flask of heavy pyrex glass having a diameter of 13 centimeters, a neck 17 centimeters long with a 3 centimeter diameter and with a side tubulus 8 centimeters above the body of the flask. The tubulus is set at approximately 75° to the neck of the flask. The condenser tube is 36 inches long and the water jacket is 30 inches long. The details of the set-up are shown on page 310.

The oil to be used should be as nearly as possible free from water. Eight hundred cubic centimeters are poured into the distillation flask, the thermometer used is preferably for 5 inch immersion reading to 750°F. It is inserted so that the top of the mercury bulb is even with the bottom of the tubulus and is in the center of the neck of the flask.

Distillation is begun using a smoky flame of a strong Tirrell burner, the flask being supported on a ring as shown in the diagram. The burner is protected from air drafts and the flask is blanketed with asbestos paper if necessary. The flame is controlled by a screw pinch cock on the rubber tubing.

The temperature at which the first drop falls from the condenser is the initial boiling point. The rate of distillation after the first 5% is 8 cubic centimeters or 1% per minute. Five per cent fractions are collected in the 100 cubic centimeter cylinder. These 40 cubic centimeters are poured into a 50 cc. graduate, allowing the distillate to mix thoroughly. The specific gravity is taken and the corrections are made to 60°F. The end point of each 2½% fraction is recorded and the distillation is continued, taking the gravity of each 5% fraction. In operating on a crude oil in which the natural content is desired, the distillation with straight fire is stopped when the first fraction with a temperature above 572°F is completed. Beyond this temperature inert gas, such as natural gas, coal gas or carbon dioxide is introduced sufficiently to carry the distillation at the same rate of speed but such that the temperature at no time exceeds 650°F. After the gas is used the water is removed from the condenser and the condenser tube is kept warm to prevent wax occluding the tube.

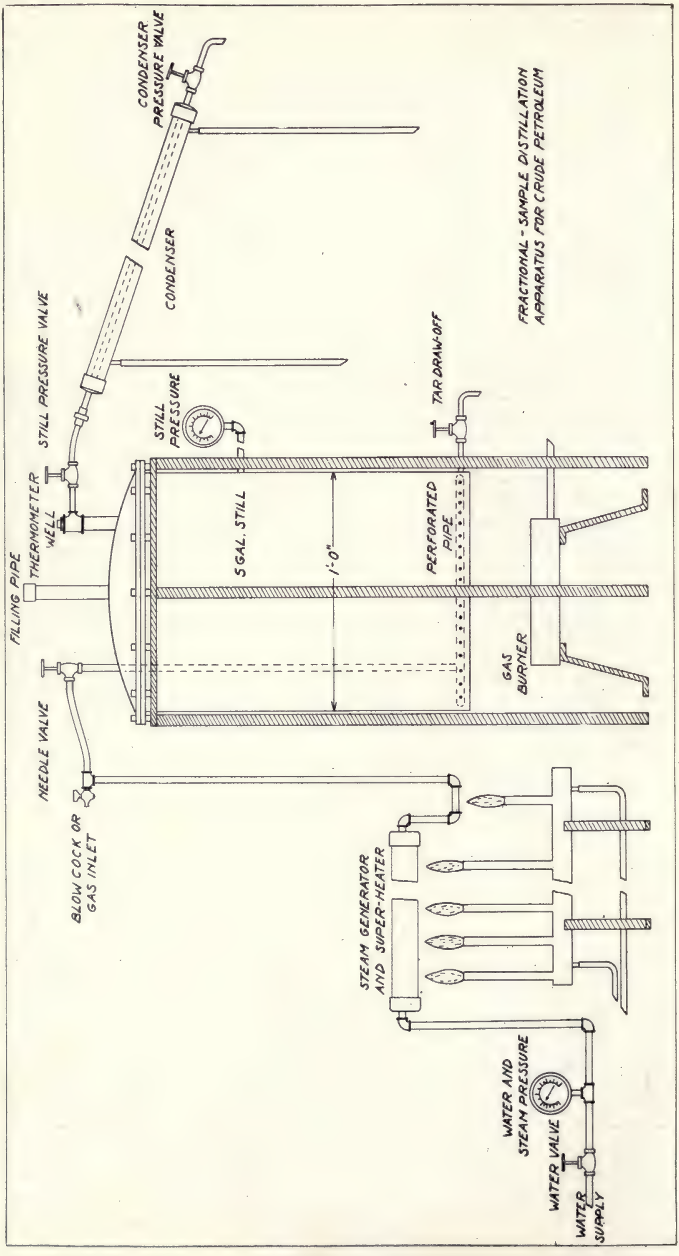
Ninety per cent should be carried over and the gravity of the residue taken.

The data obtained by this distillation is shown on pages 122 to 127 for crude oil, on pages 231-2 for gasoline and page 230 for heavy distillate.

## 9D. SAMPLE PREPARATION DISTILLATION OF CRUDE OIL.

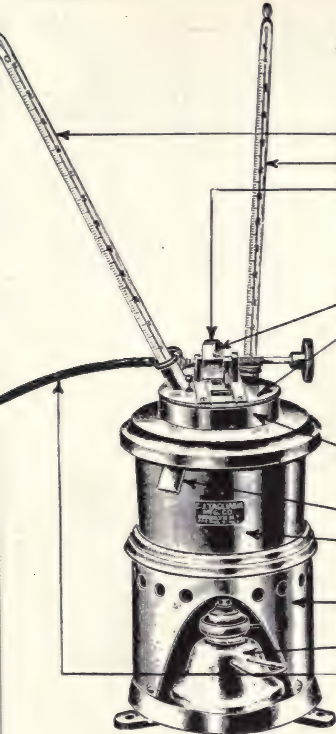
The apparatus consists of a 5-gallon steel still, condenser, gas burner, water supply under pressure, steam producers, superheater gauges and connections as shown on page 312.

Ten thousand cubic centimeters is a convenient charge, giving a 5% fraction of 500 cc., which is sufficient for special tests. The still is covered with chicken wire and asbestos cement for insulation. Direct firing is used until a temperature of slightly above 500°F is indicated in the vapor or a gravity of 40°Be′ (0.825 specific gravity) is shown in the distillate fraction. At this temperature superheated steam or gas is introduced.




FRACTIONAL-SAMPLE DISTILLATION
APPARATUS FOR CRUDE PETROLEUM

## The "TAG" standard closed flash tester for volatile inflammable liquids



(A) Thermometer, indicating the temperature of the oil.

(B) Thermometer, indicating the temperature of the water bath.

(C) A miniature oil well to supply the test flame when gas is not available, mounted on the axis about which the test-flame burner is rotated, which axis is hollow and provided with connection on one end for gas hose, and provided also with needle valve for controlling gas supply, when gas is available, the gas passing through the empty oil well.

(D) Gas or oil tip for test flame.

(E) Cover for oil cup, provided with three openings, which are in turn covered by a movable slide operated by a knurled hand knob, which also operates the test flame burner in unison with the movable slide, so that by turning this knob the test flame is lowered into the middle opening in the cover, at the same time that this opening is uncovered by the movement of the slide.

(F) Oil cup (which cannot be seen in the illustration), of standardized size, weight and shape, fitting into the top of the water bath.

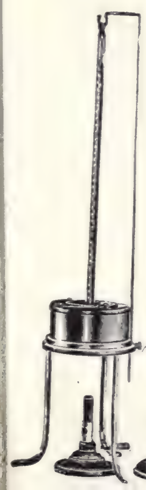
(G) Overflow spout.

(H) Water bath, of copper, fitting into the top of the body, and provided with an overflow spout and openings in its top, to receive the oil cup and water bath thermometer.

(J) Body of metal, attached to substantial cast metal base provided with three feet.

(K) Alcohol lamp for heating the water bath.

(L) Gas hose.



Cleveland open tester for flash point and burning point of heavy oils.


New York closed tester for all types of oils. (Elliott)

## 10A. FLASH POINT OF KEROSENE AND OTHER VOLATILE INFLAMMABLE LIQUIDS.

**(With Standard "TAG" Closed Tester.)**

This is essentially in accordance with the method of the American Society for Testing Materials, Tentative Standards, 1917, pages 445-6.

The test must be performed in a dim light so as to see the flash plainly.

Surround the tester on three sides with an inclosure to keep away drafts. A shield about 18 inches square and 2 feet high, open in front, is satisfactory. See that tester sets firmly and level.

For accuracy, the flash point thermometers which are especially designed for the instrument should be used as the position of the bulb of the thermometer in the oil cup is essential.

Put the water-bath thermometer in place. Place a receptacle under the overflow spout to catch the overflow. Fill the water bath with water at such a temperature that when testing is started, the temperature of the water bath will be at least 10°C below the probable flash point of the oil to be tested.

Put the oil cup in place in the water bath. Measure 50 cc. of the oil to be tested in a pipet or a graduate and place in oil cup. The temperature of the oil must be at least 10°C below its probable flash point when testing is started. Destroy any bubbles on the surface of the oil. Put on cover with flash point thermometers in place and gas tube attached. Light pilot light on cover and adjust flame to size of the small white bead on cover.

Light and place the heating lamp, filled with alcohol in base of tester and see that it is centrally located. Adjust flame of alcohol lamp so that temperature of oil in cup rises at the rate of about 1°C (1.8°F) per minute or not faster than 1°C (1.8°F) nor slower than 0.9°C (1.6°F) per minute.

Record the "time of applying the heating lamp," record the "temperature of the water bath at start," record the "temperature of the oil sample at start."

When the temperature of the oil reaches about 5°C below the probable flash point of the oil, turn the knob on the cover so as to introduce the test flame into the cup and turn it promptly back again. Do not let it snap back. The time consumed in turning the knob down and back should be about one full second, or the time required to pronounce distinctly the words "one thousand and one."

Record the "time of making the first introduction of the test flame" and record the "temperature of the oil sample at time of first test."

Repeat the application of the test flame at every 0.5°C rise in temperature of the oil until there is a flash of the oil within the cup. Do not be misled by an enlargement of the test flame or halo around it when entered into the cup or by slight flickering of the flame; the true flash consumes the gas in the top of the cup and causes a very slight puff.

Record the "time at which the flash point is reached," and the "flash point."

If the rise in temperature of the oil from the "time of making the first introduction of the test flame" to the "time at which the flash point is reached" was faster than 1.1°C or slower than 0.9°C per minute, the test should be questioned and the alcohol heating lamp

adjusted so as to correct the rate of heating. It will be found that the wick of this lamp can be so accurately adjusted as to give a uniform rate of rise in temperature of 1°C per minute and remain so.

Repeat Tests.—It is not necessary to turn off the test flame with the small regulating valve on the cover, but leave it adjusted to give the proper size of flame.

Having completed the preliminary test, remove the heating lamp, lift up the oil cup cover and wipe off the thermometer bulb. Lift out the oil cup and empty and carefully wipe it. Throw away all oil samples after once using in making test.

Pour cold water into the water bath, allowing it to overflow into the receptacle until the temperature of the water in the bath is lowered to 8°C below the flash point of the oil as shown by the previous test. With cold water of nearly constant temperature it will be found that a uniform amount will be required to reduce the temperature of the water bath to the required point.

Place the oil cup back in the bath and measure into it a 50 cc. charge of fresh oil. Destroy any bubbles on the surface of the oil, put on the cover with its thermometer, put in the heating lamp, record time and temperature of oil and water and proceed to repeat test as described above. Introduce test flame for first time at a temperature 5°C below the flash point obtained on the previous test.

Precautions.—Be sure to record barometric pressure either from laboratory barometer or from nearest Weather Bureau station. Record temperature of room.

Note and record any flickering of the test flame or slight preliminary flashes when the test flame is introduced into the cup before the proper flash occurs. Record time and temperature of such flickers or slight flashes if they occur.

## 10B. FLASH AND BURNING POINT OF ALL TYPES OF PETROLEUM OILS AND ASPHALTS.

**(With New York or Elliott Closed Tester.)**

The bath surrounding the oil cup is filled with very high flash fluid oil or is left unfilled if the oil to be tested has a very high flash point. The oil cup is filled with the material to be tested to within 3 millimeters of the flange joining the cup and the vapor chamber above. The glass cover is then placed on the oil cup and the thermometer adjusted so that its bulb is just covered by the oil or bitumen. The flame is applied to the bath in such manner that the temperature is raised at the rate of about 5°C per minute. Every half minute the testing flame is inserted in the opening in the cover and about halfway between the surface of the material and the cover. The first appearance of a faint bluish flame on the entire surface of the bitumen or oil shows that the flash point has been reached, and this temperature is recorded.

**The burning point** of the material is now obtained by removing the glass cover and replacing the thermometer in the frame. The temperature is raised at the same rate and material tested as before. The temperature at which the oil or bitumen ignites and burns is recorded as the burning point. The flame should be extinguished with the metal cover very promptly after the burning point is reached.

## 10C. FLASH AND BURNING POINT OF LUBRICANTS.
### (With the Cleveland Open Cup.)

The lubricating oil is poured into the oil cup to within 5 mm. of the top. The flame is then applied to the air bath in such manner that the temperature of the oil in the cup is raised at the rate of 5°C per minute. The testing flame is made from a piece of drawn glass tubing, making a flame about 5 mm. in length. This flame is applied to the surface of the oil every half minute. A distinct flicker or flash over the entire surface of the oil shows that the flash point is reached and the temperature at this time is recorded.

The **burning point** of the oil is obtained by continuing the test and noting the temperature at which the vapor arising from the surface of the oil ignites and burns continuously. The thermometer is quickly withdrawn and the metal cover used to extinguish the flame.

## CONVERSION OF BAROMETRIC PRESSURE IN CENTIMETERS TO INCHES.

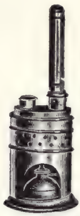
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 70 | 27.559 | 27.598 | 27.638 | 27.677 | 27.716 | 27.756 | 27.795 | 27.835 | 27.874 | 27.913 |
| 71 | 27.953 | 27.992 | 28.031 | 28.071 | 28.110 | 28.150 | 28.139 | 28.228 | 28.268 | 28.307 |
| 72 | 28.346 | 28.386 | 28.425 | 28.465 | 28.504 | 28.543 | 28.583 | 28.622 | 28.661 | 28.701 |
| 73 | 28.740 | 28.779 | 28.819 | 28.858 | 28.898 | 28.937 | 28.976 | 29.016 | 29.055 | 29.094 |
| 74 | 29.134 | 29.173 | 29.213 | 29.252 | 29.291 | 29.331 | 29.370 | 29.409 | 29.449 | 29.488 |
| 75 | 29.528 | 29.567 | 29.606 | 29.646 | 29.685 | 29.724 | 29.764 | 29.803 | 29.842 | 29.882 |
| 76 | 29.921 | 29.961 | 30.000 | 30.039 | 30.079 | 30.118 | 30.157 | 30.197 | 30.236 | 30.276 |
| 77 | 30.315 | 30.354 | 30.394 | 30.433 | 30.472 | 30.512 | 30.551 | 30.590 | 30.630 | 30.669 |

## CORRECTIONS OF FLASH POINT FOR NORMAL BAROMETRIC PRESSURES.

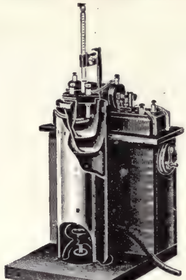
To correct readings made at other pressures to the standard barometric pressure of 760 mm.

| Barometer Millimeters | Correction Degrees C. |
|---|---|
| 700 | — 2.1 |
| 705 | — 1.9 |
| 710 | — 1.7 |
| 715 | — 1.6 |
| 720 | — 1.4 |
| 725 | — 1.2 |
| 730 | — 1.0 |
| 735 | — .9 |
| 740 | — .7 |
| 745 | — .5 |
| 750 | — .3 |
| 755 | — .2 |
| 760 | 0 |
| 765 | + .2 |
| 770 | + .4 |
| 775 | + .5 |
| 780 | + .7 |
| 785 | + 9 |

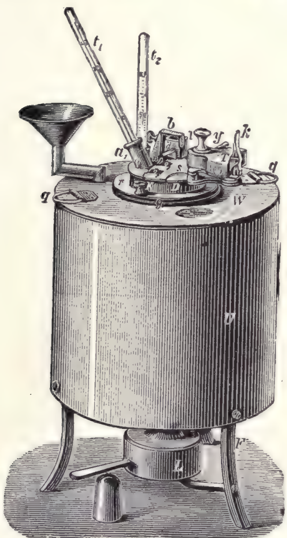
Abel-Pensky



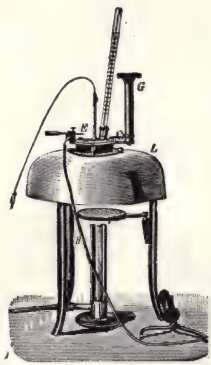
Foster



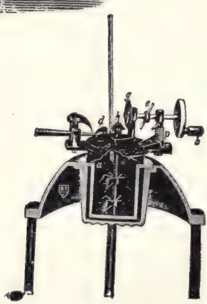
Scott



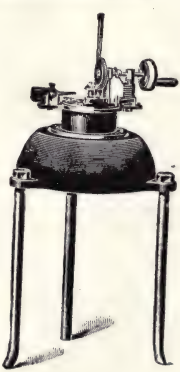
Abel



Pensky-Martens



Gray



VARIOUS FLASH AND FIRE TESTERS.

## 11A. CRACKING TEST FOR HEAVY PETROLEUM HYDROCARBONS. (See P. 320.)

The apparatus is set up as shown in sketch. (a) is a cylindrical tube tested out to a pressure of 3,000 pounds such as is ordinarily used for dispensing oxygen gas. (b) is a thermometer well or plug with a tapered thread and of sufficient length that it protrudes well into the interior of the vessel (a). This plug has an opening from the outside into which the thermometer (c) is inserted. This mercury thermometer is graduated preferably in single degrees Centigrade and is of borosilicate glass, nitrogen filled and reading up to a temperature of 550°C. (d) is an extra heavy ammonia pipe fitting connected to a valve (e) and a pressure gauge (f). Pressure gauge (f) should read to at least 200 atmospheres or 200 kilograms per square centimeter. Heat is applied by gas burners (g) such as are used in combustion furnaces and the whole apparatus is supported on a stand with the end carrying the pressure gauge slightly elevated.

The capacity of the bomb is 1,500 to 1,600 cubic centimeters and 500 cc. of oil to be tested are poured into it at a temperature of approximately 20°C. The plug (b) is inserted and screwed in very tightly, using Stilson wrenches. The threads on the plug may be dressed with a mixture of equal parts of glycerin, litharge and copper oxide. The flame is applied so that it does not excessively heat the portion of the container not in contact with the oil. The total time consumed for the test after the beginning of the application of the heat should be between 55 minutes and 70 minutes. The heating is carried on until a pressure of 55 atmospheres is attained, based on a temperature of 400°C. It is desirable to keep the container covered with a sheet of asbestos during the operation. The temperature should not ordinarily exceed 420°C. The apparatus is cooled to about 20°C before opening.

The constants in this test are the dimensions of the apparatus, the amount of oil used, the rate of application of heat and maximum pressure at 400°C.

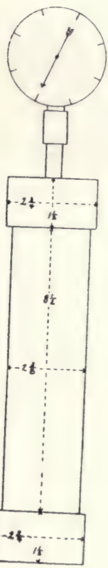
The variables are the percentage by volume of oil recovered after cracking, the amount of carbon formed, the amount of gas formed, the specific gravity of the gasoline and the total yield of gasoline. (See proximate distillation of crude oil.)

Variations are due to the character of the oil treated, the specific gravity of the gasoline being higher, the recovery higher, the carbon and gas formation less and the total amount of oil recovered greater with paraffin base and with low gravity oils than with naphthene base and high gravity oils.

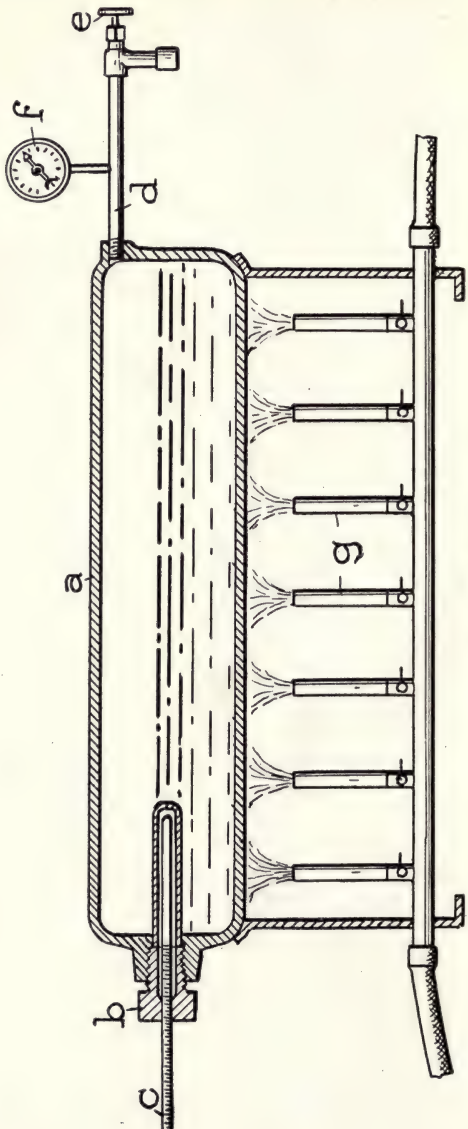
From one such equilibrium test it is possible to approximately estimate the amount of total gasoline which it would be possible to obtain from an oil. This may be calculated from one equilibrium test by taking into consideration the shrinkage on cracking and the increase in specific gravity of the residue above 210°C after cracking. (See pages 228-9.)

## 11B. VAPOR PRESSURE.

The vapor pressure of light petroleum hydrocarbons is determined with the same apparatus used for making the cracking test. The pressure readings with the corresponding temperature readings should be taken every 30 pounds and a curve plotted for intermediate points. The temperature should not be carried above 350°C as cracking will take place. (See curves on page 226.)



Vapor
Pressure
Tester.




Pressure Cracking Apparatus

## 11C. VAPOR PRESSURE TESTS FOR LIGHT GASOLINE MADE FROM GAS.

**(See Westcott, Handbook of Casinghead Gasoline.)**

Apparatus shown on page 320 consists of iron or steel pipe of 2 inch size, with caps screwed on ends. Upper cap has 0.25 inch nipple screwed in and is connected by a coupling to a 3 inch 30 lb. pressure gauge. Gauge is known as Inspector's Gas Gauge. All joints must be entirely tight. Joints between large pipe and caps are best sealed with solder. Approximate external dimensions are indicated on sketch. In addition to apparatus indicated in test, there is also required a tin cylinder for filling test tube, 12 by 3 inches, that can be slipped over outside of tube for convenience in carrying when not in use. The tin cylinder is provided with a lip for pouring. A small tin cover 0.75 inch deep, fitting over the bottom of the tin cylinder may be removed and used for measuring off one-tenth capacity of test tube. A small tin funnel 2.5 inches in diameter with stem 3 inches long and three-sixteenths inch in diameter should be used.

Remove the gauge from the tube and fill tube to 90 per cent of its capacity. Fill tube preferably by lowering it into the storage tank in upright position by means of a cord or wire. Leave the tube entirely immersed for several minutes, withdraw it and pour off sufficient liquid so that tube will contain 90% of its capacity. A small measure having capacity of 10% of the test tube should be used for that purpose.

In case it is impracticable to lower the tube into the storage tank, draw the liquid off into the vessel of capacity about equal to the test tube. Pour liquid into the test tube until about half filled. Shake tube and contents gently in order to bring both to the same temperature. After standing for several minutes, pour out all the liquid from the tube. Draw another sample from the storage tank into the cylinder and pour through funnel into the tube until the latter is entirely full. Withdraw one-tenth as before. Screw gauge tightly into position, using a little liquid shellac on joint to insure a tight fit.

Immerse the tube in water at temperature of 70°F and allow it to remain for five minutes. Then remove it from the water and unscrew the gauge sufficiently to relieve the pressure indicated by the gauge for a period of 20 seconds and screw the gauge tightly into the tube again. Then place the tube in water at a temperature of 100°F (~~90°F from Nov. 1st to March 1st~~). The level of the water must be just below the lower edge of the pressure gauge. Stir the water continually and maintain the temperature exactly constant for ten minutes, then tap the gauge lightly with the finger and read the pressure.

A correction of pressure figures should be made according to the initial temperature of the gasoline. This correction should be as follows:

For tests on samples taken at a temperature of 50 to 59°F, inc., deduct 1 lb.

For tests on samples taken at a temperature of 40 to 49°F, inc., deduct 2 lbs.

For tests on samples taken at a temperature below 40°F, deduct 3 lbs.

The gravity of the liquid, the temperature of liquid gas placed in test tube, the pressure at 70°F before venting tube, the corrected pressure at 100°F (90°F from Nov. 1st to March 1st) after venting at 70°F should all be recorded.

## 12A. CARBON RESIDUE IN LUBRICANTS AND DISTILLATES. (Conradson Method.)

The apparatus consists of:

(a) Porcelain crucible, wide form, glazed throughout, 25 to 26 cc. capacity, 46 mm. in diameter.

(b) Skidmore iron crucible, 45 cc. (1½ oz.) capacity, 65 mm. in diameter, 37 to 39 mm. high with cover, without delivery tubes and one opening closed.

(c) Wrought iron crucible with cover, about 180 cc. capacity, 80 mm. diameter, 58 to 60 mm. high. At the bottom of this crucible a layer of sand is placed about 10 mm. deep, or enough to bring the Skidmore crucible with cover on nearly to the top of the wrought iron crucible.

(d) Triangle, pipe stem covered, projection on side so as to allow flame to reach the crucible on all sides.

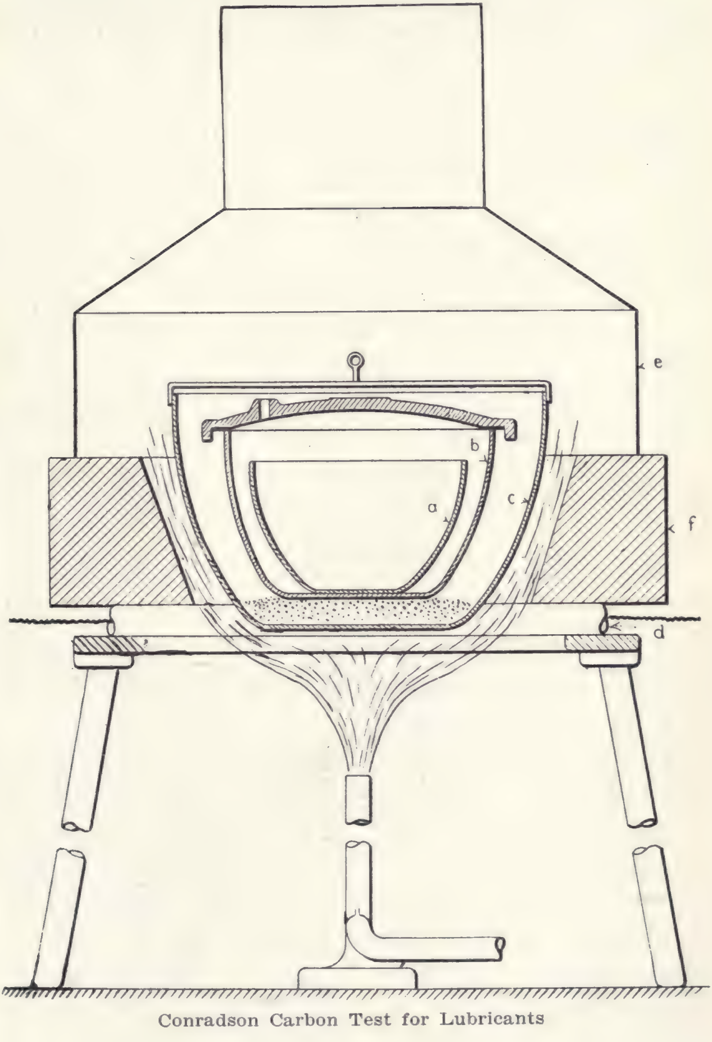
(e) Sheet iron or asbestos hood provided with a chimney about 2 to 2½ inches high, 2⅛ to 2¼ inches in diameter to distribute the heat uniformly during the process.

(f) Asbestos or hollow sheet iron block, 6 to 7 inches square, 1¼ to 1½ inches high, provided with opening in center 3¼ inches in diameter at the bottom and 3½ inches in diameter at the top. The test shall be conducted as follows:

Ten grams of the oil to be tested are weighed in the porcelain crucible, which is placed in the Skidmore crucible and these two crucibles set in the larger iron crucible, being careful to have the Skidmore crucible set in the center of the iron crucible, covers being applied to the Skidmore and iron crucibles. Place on triangle and suitable stand with asbestos block and cover with sheet iron or asbestos hood in order to distribute the heat uniformly during the process.

Heat from a Bunsen burner or other burner is applied with a high flame surrounding the large crucible, as shown in Fig. 1, until vapors from the oil start to ignite over the crucible, when the heat is slowed down so that the vapor (flame) will come off at a uniform rate. The flame from the ignited vapors should not extend over 2 inches above the sheet iron hood. After the vapor ceases to come off, the heat is increased as at the start and kept so for five minutes, making the lower part of large crucible red hot after which the apparatus is allowed to cool somewhat before uncovering the crucible. The porcelain crucible is removed, cooled in a dessicator and weighed.

The entire process should require about one-half hour to complete when heat is properly regulated. The time will depend somewhat upon the kind of oil tested, as a very thin, rather low flash-point oil will not take as long as a heavy, thick, high flash-point oil. (See A. S. T. M. 1918 Standards, page 620.)

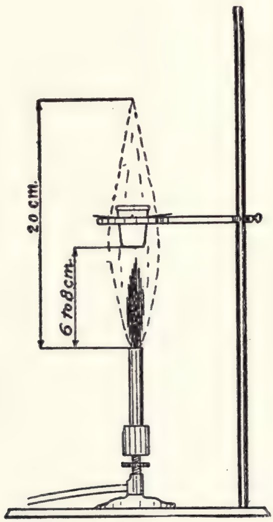



Conradson Carbon Test for Lubricants

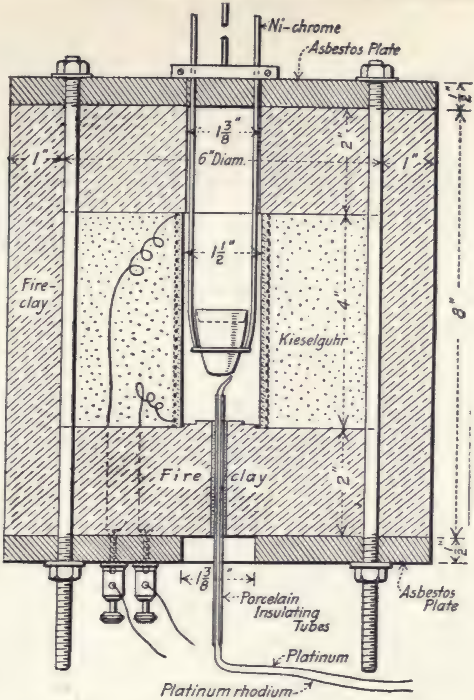
## 12B. FIXED CARBON AND ASH IN OIL AND BITUMINOUS MATERIALS.

The apparatus used is that shown below, or if the apparatus used for the analysis of coal is available, the special furnace shown on page 325 may be used, or the electric furnace shown on page 348, such as is used for burning out mineral aggregates, is quite satisfactory.

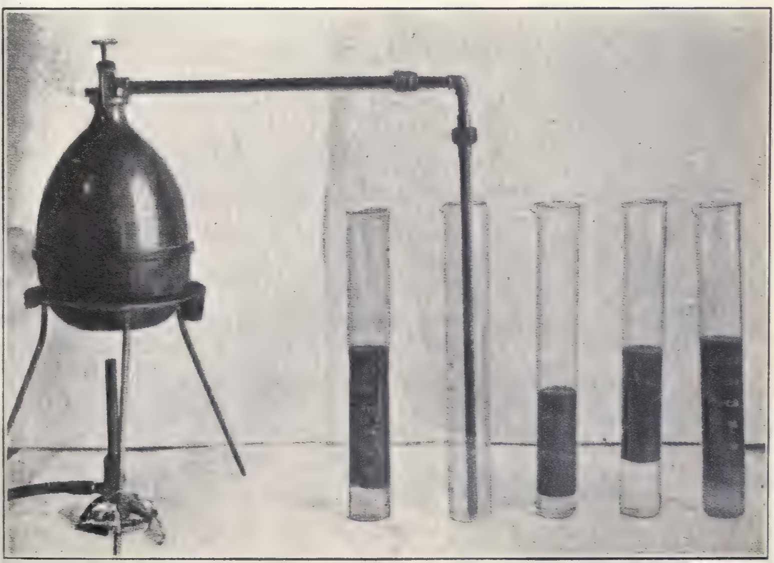
Between .4500 and .5500 gram of the material is placed in a 20-gram platinum crucible having a tightly fitting cover. It is heated for seven minutes with the full flame of a Bunsen burner, as shown, or at 950°C in the electric furnace. With the open flame the crucible should be supported with its bottom 6 or 8 cm. above the top of the burner and the flame should be at least 20 cm. high when burning freely. A shield is used to protect from drafts. The crucible while remaining covered is placed in a dessicator, cooled and weighed, then ignited with lid removed until nothing but the ash remains. The loss is the fixed carbon and the residue is the ash.




Apparatus for the Determination of Fixed Carbon




Electric Furnace for Fixed Carbon



## 13. EMULSIFICATION OF MINERAL LUBRICATING OILS. (A. S. T. M.—1916.)

P. H. Conradson.

**Apparatus.**

The apparatus consists of a 4-pint copper retort, provided with a delivery tube, which is joined to a metal or glass pipe having an inside diameter of about 5/16 in. and about 15 in. long from the elbow. The lower end of this pipe is cut off diagonally to prevent thumping.

The glass cylinders are graduated to 250 cc. They have an inside diameter of about 1 7/16 in. and a length of about 9½ in. from the bottom to the 250 cc. mark. They are 11½ to 12 in. in over-all length, and are made of thin glass, with a flat bottom.

In place of a copper retort for the generation of steam, a glass flask or any other suitable source of steam supply may be used; likewise, ordinary 250 cc. graduated glass cylinders, of dimensions given above, may be used where emulsion tests are required only occasionally.

**Method of Testing.**

The cylinder is filled with distilled water up to the 20 cc. mark, then 100 cc. of the oil to be tested are added. To churn the mixture, steam at ordinary pressure is conducted through this oil-water mixture for ten minutes. The amount of steam passed through is regulated in such a way so as to prevent the mixture from splashing over the top of the cylinder, but the rate may be as rapid as is practical. This is easily regulated by the height of the gas flame.

The churning is begun from the time the temperature of the mixture has reached 200°F, or when the steam as such passes off the mixture. It usually takes from 1 to 1½ minutes to reach this temperature, depending somewhat on the body or viscosity of the oil. However, even churning with steam for 15 minutes does not seem to make any difference in the results.

When the churning is completed, the cylinder is immersed for one hour in a water bath, kept at a temperature of 130°F. During this time the cylinder and its contents are momentarily inspected at intervals to note the behavior of the oil mixture. At the expiration of one hour the cylinder is removed from the water bath and the contents are examined for the following:

1. The number of cubic centimeters of separated clear or turbid water.
2. The number of cubic centimeters of separated emulsified layer.
3. The number of cubic centimeters of separated clear or turbid oil above the emulsified layer; and
4. The percentage of water or moisture in the separated oil above the emulsified layer.

The number of cubic centimeters and condition of the emulsified layer is an indication of the emulsion-forming property, or quality of the oil.

The number of cubic centimeters of clear or turbid oil above the emulsified layer, less the percentage of water or moisture contained in the oil, is the percentage of demulsibility of the oil.

The condition of the separated water or watery liquid under the emulsified layer, if any, gives an indication also of the behavior of the oil in actual service.

The amount of water held in the oil above the emulsified layer may be determined as follows:

The oil above the emulsified layer after the expiration of the test is carefully drawn off and shaken; then 20 cc. are mixed with 80 cc. of 88° Baume′ gasoline (from Pennsylvania Crude) in a graduated, flat-glass precipitating tube having the lower end drawn out. The oil-gasoline mixture is kept at a temperature not over 80°F for one hour, or the water or watery liquid may be separated from the oil-gasoline mixture by means of a centrifuge. The amount of water or watery liquid is read off and calculated to percentage by volume and subtracted from the oil above the emulsified layer. Of course, this determination is only necessary when the oil above the emulsified layer appears to contain an appreciable amount of water.

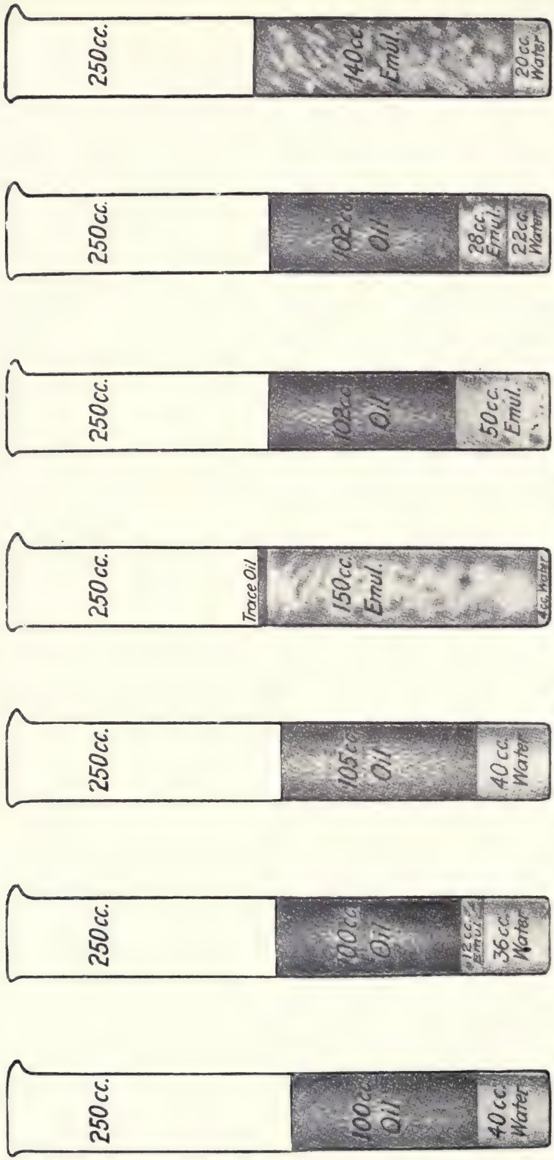
**Interpretation of Results.**

Page 328 illustrates the behavior of seven representative oils with this method, as they appear after expiration of the tests.

Table I gives detailed results of tests of these oils. The first turbine oil shows the oil entirely free from emulsifying property or elements, only retaining a very small percentage of moisture or water after the expiration of the test. The second turbine oil shows quite

**TABLE I.—EMULSIFICATION TESTS OF LUBRICATING OILS.**

| Oil No. | Kind of oil | Separated water, etc. | Condition of Water | Emulsified layer, etc. | Kind of emulsion | Separated oil, etc. | Condition of oil | Moisture in oil % | Demulsibility % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Turbine | 40 | Clear | None | ..... | 100 | Slightly turbid | 0.2 | 99.8 |
| 2 | Turbine | 36 | Slightly turbid | 12 | Light foamy | 100 | Turbid | 1.0 | 99.0 |
| 3 | Crank case | 40 | Clear | None | ..... | 105 | Very turbid | 5.0 | 95.0 |
| 4 | Crank case | 4 | Clear | 150 | Heavy thick | Trace | Practically all emulsion | ... | 0.0 |
| 5 | Engine | None | ..... | 50 | Thick milky | 102 | Very turbid | 4.0 | 96.0 |
| 6 | Engine | 22 | Clear | 28 | Light foamy | 102 | Turbid | 3.0 | 97.0 |
| 7 | Spindle | 20 | Milky | 140 | Thick milky | None | All emulsion | ... | 0.0 |




Results of Emulsification Tests

a little of emulsified layer, but the condition of the emulsifier layer is light and foamy, not compact or creamy. The amount of water or moisture retained in the oil is much higher than in the first oil.

Consider next the two samples of crank-case oil: The first oil shows ready separation of water, which is clear and has no emulsified layer, but the oil after the test retains about 5 per cent of water. With the other crank-case oil only a very few cubic centimeters of water are separated at the expiration of the test, and a very large amount of emulsified layer of a heavy thick nature is shown; in fact the whole mixture is a heavy emulsion without separation.

The first sample of engine oil shows at the end of the test a thick milky emulsion with practically no separation of water, and the separated oil above the emulsified layer about 4 per cent of water. The second sample of engine oil shows considerable amount of separation of water and much smaller amount of emulsified layer; this layer is of a light foamy nature.

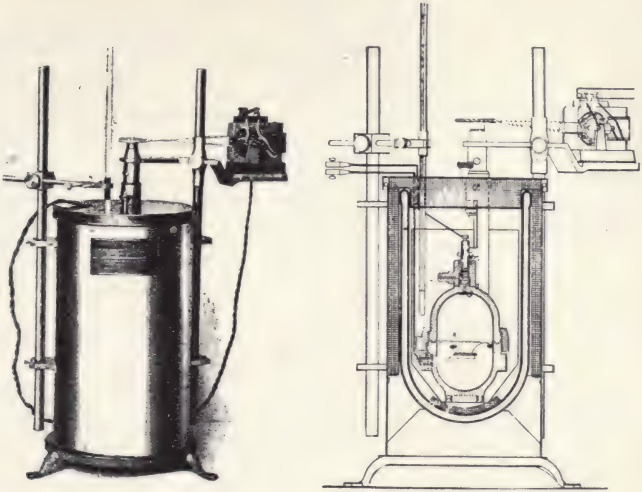
It should be particularly noticed in these two cases that while 100 cc. of oil were used in the tests, 102 cc. of separated turbid oil were found; deducting the amount of moisture or water found in the separated oil, 4 and 3 per cent, respectively, gives 96 and 97 per cent of demulsibility. This is a clear illustration of the importance of giving a complete statement in the report of the behavior of the oil or oils in the emulsifying test, as simply stating the percentage of demulsibility is clearly insufficient, and in cases of this kind would be seriously misleading.

## 14. HEATING VALUE OR CALORIFIC VALUE OF PETROLEUM PRODUCTS.

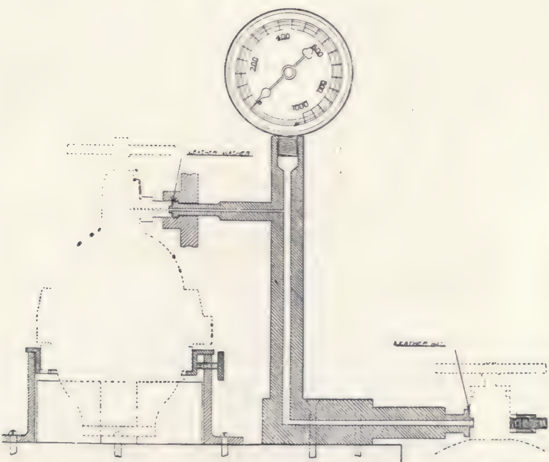
The apparatus used for the heating value, calorific value or British thermal units of petroleum products are shown on pages 331 and 334.

Any type of oxygen bomb calorimeter is satisfactory. Among these are the Atwater, Mahler, Parr and Kroeker bombs. The so-called Parr chemical calorimeter is not satisfactory either in operation or results when applied to oil. The description of the operation of one bomb calorimeter is typical of all.

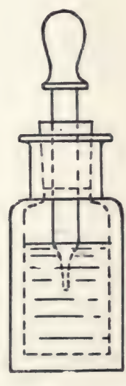
The lower half of the bomb is placed in the cast iron holder. About one gram of the oil is weighed to the nearest 0.0001 gram into the fuel pan and is placed in the bomb on the fuel pan holder. If the oil is volatile it is not advisable to pour the fuel directly into the fuel pan. For this purpose, small gelatine capsules weighing .1 gm. are used and may be filled with ignited asbestos and into this the light oil is discharged from a weighing pipet. The capsule is immediately closed leaving a minimum amount of air space. A similar capsule has been previously weighed and its calorific value determined. A stock of standardized capsules should be kept on hand in an air tight receptacle. The platinum fuse wire is cut equal in length to the taper pin wrench which is connected to the terminal being careful that it does not touch the pan. The wire is bent down so that it is covered by the oil or by the lips of the capsule. The upper half of the bomb is carefully fitted on the lead gasket to the lower half. The nut is screwed down over the upper half being careful not to cross the threads. The bomb nut is now tightened by the use of the long wrench, being careful to cause no sudden jerking or vibrating which will throw the oil from the pan. The bomb is now carefully lifted out and placed on the swivel table and connected with the oxygen piping. The valve in the top of the bomb is opened about one turn and the valve in the oxygen cylinder is carefully and slowly opened so that the pressure in the bomb as shown by the indicator rises to 300 pounds. The bomb valve is now closed and the oxygen cylinder valve is closed. Exactly 1900 grams of water at a temperature of about 4° below room temperature is weighed into the calorimeter water bucket. This is placed in the calorimeter container. The bomb is connected with the electric wire and is introduced into the water being careful to place it in the center of the bucket. Two 100 watt lamps placed in parallel are in series with the fuse wire when a 110 volt circuit is used for firing. The stirring motor is placed in series with a 60 watt lamp on a 110 volt circuit. The cover is put on, the connections to the bomb wire are made and the stirrer is introduced as far down as it will go. It should not touch the bomb. The thermometer is introduced and stirring is continued for about 5 minutes. The temperature is read and the stirring continued for exactly 5 minutes and the temperature is again read and the charge is fired by quickly throwing in the switch and withdrawing it. The stirring is continued for 5 minutes, the temperature being read at minute intervals or at the end of 5 minutes unless extreme accuracy is required. The stirrer is then run for an additional 5 minutes and the temperature is again read. The thermometer is corrected in accordance with the corrections furnished by the Bureau of Standards. The radiation corrections may be applied to each one minute interval



Calorimeter Equipped With Vacuum Walled Jacket




Oxygen Connection



Weighing Bottle
for Liquid Fuels, etc

but for ordinary purposes 1/5 of the radiation for the 5 minute period before firing is applied on the 5 minute period immediately after firing and 4/5 of the radiation in the third 5 minute period is applied on the 5 minute period immediately after firing. The calorimeter constant (usually about 2400) is determined by a blank test using exactly 1 gram of benzoic acid. This constant always remains the same with the same calorimeter but must be determined each time a change is made in the calorimeter. In the case of oil in which it has been necessary to use the capsule the correction made must be applied for the calorific value of the capsule. This is most conveniently applied to the corrected net rise in temperature of the thermometer. To convert British thermal units per pound to calories per gram, multiply by 5/9. To obtain the water evaporative power, multiply the B. T. U. per pound by 1.035. To obtain the B. T. U. per gallon, multiply the B. T. U. per pound by the weight per gallon.

An approximation of the heating value of fuel oil can be obtained by the following formula:

B. T. U. in lbs. per gallon $= 18700 + 40$ (°Be′—10).

## 15-A. SULPHUR FROM THE BOMB CALORIMETER.

The calorimeter is opened by gradually allowing the pressure to diminish and the bomb is carefully and thoroughly washed out with distilled water. The pan is placed in the beaker with the washings and about 10 cc. of hydrochloric acid is added. The contents of the beaker are treated with bromine, heated to boiling temperature for about 10 minutes, filtered and washed and the sulphur in the filtrate precipitated with 10 cc. of barium chloride solution. The precipitated barium sulphate is filtered, washed and weighed in the usual manner. The weight of the barium sulphate $\times$ 13.733 and divided by the weight of the sample gives the percentage of sulphur in the oil.

## 15-B. SULPHUR BY THE ESCHKA METHOD.

This method is not good for oils, in most instances giving a low result, but may be used where accuracy is not necessary. Weigh out approximately 1 gram of the oil and mix it with 2.5 grams of sodium carbonate and 5 grams of calcined magnesia in a platinum dish or crucible. Heat gradually increasing the temperature until the mass has a low red color and the mixture on cooling has a grayish tint. Cool and wash into a 500 cc. beaker with distilled water and add about 1 cc. of bromine. Mix until the bromine is thoroughly dissolved and allow some time for the bromine to react. Now add hydrochloric acid until the reaction is decidedly acid, the beaker being covered in the meantime to prevent any mechanical loss. Filter off and wash any undissolved residue. Precipitate in the usual manner with barium chloride and weigh as barium sulphate.

## 15-C. SULPHUR WITH THE PARR CHEMICAL CALORIMETER.

Weigh 0.25 — 0.40 gram of the oil from a weighing pipet into the Parr chemical bomb container along with a mixture of 1 gram of 100 mesh potassium chlorate and 1 full measure, using the cup furnished with the instrument, of pure sodium peroxide. Add 0.2500 gm. of sulphur free lampblack. Immediately close and lock the bomb and be sure that the spring in the plunger valve is strong. Shake thoroughly until the lampblack, the oil, the potassium chlorate and the sodium peroxide are thoroughly mixed. Place the bomb in the calori-

meter with the stirring wings adjusted on it and add 2000 cc. of water.

Put the cover on the calorimeter and introduce the thermometer and stir. Heat a hot wire slug about ¼-inch long and when red, quickly introduce into the stem of the calorimeter. As quickly as possible with a quick thrust of the plunger allow it to fall into the bomb. Stir until the temperature ceases to rise. Remove the bomb, open it and place it in a beaker. Pour boiling hot water into it until effervescence ceases. Rinse off the bomb into the beaker and remove the wire. Add hydrochloric acid until acid in reaction.

Filter, wash and to the filtrate add barium chloride. Boil a few minutes, allow to stand hot at least 15 minutes or until the supernatent liquid is clear, filter off the barium sulphate and weigh it in the usual manner. The barium sulphate × 13.73 divided by the weight of the oil taken is the percentage of sulphur.

## 16-A. CARBON AND HYDROGEN IN PETROLEUM PRODUCTS.

The most convenient method is to burn the oil in a special calorimeter bomb of the type of the Kroeker (see page 334).

The bomb must be perfectly dried on the inside by drawing dry air through the apparatus.

Approximately one gram of oil is now burned exactly as in the determination of heat of combustion (which see).

The bomb is taken from the calorimeter and is connected on the tube side with Drechsel bottles containing moist soda lime in the first bottle and calcium chloride in the second bottle. The outlet of the bomb is now connected in series with a U tube containing granulated zinc to decompose any acid formed in the combustion, with a glass stoppered U tube filled with calcium chloride of about 10 mesh size, with a glass stoppered U tube filled in the first arm with soda lime containing 10% water and the upper part of the second arm with calcium chloride connected then with an aspirator bottle.

The outlet of the bomb is gradually opened so that at least 10 minutes is required to release all of the pressure.

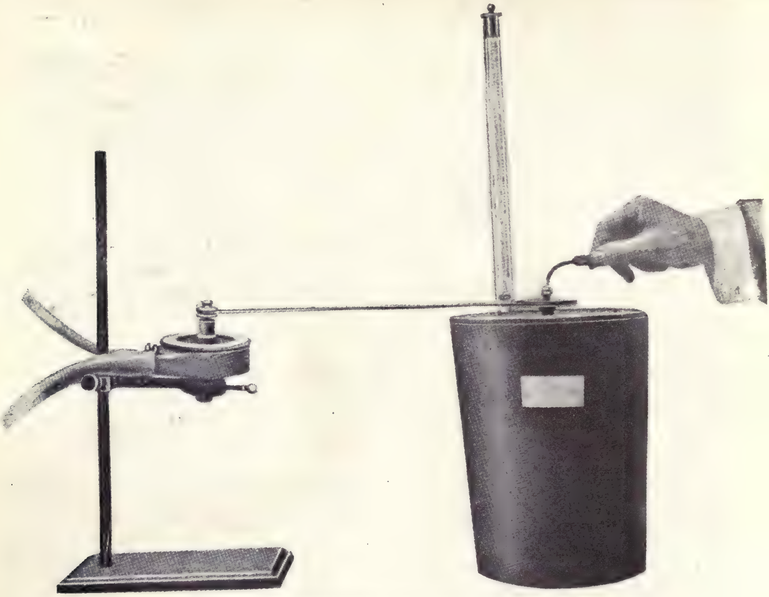
The bomb is now heated and the aspirator is run at such a rate that about five gallons of air are drawn through the bomb during a period of between one and two hours. The carbon is calculated from the increase in weight of the soda lime U tube and the hydrogren is calculated from the increase in weight of the calcium chloride U tube.

$$\frac{CO_2 \times 27.273}{\text{weight of sample}} = \%\ \text{carbon}$$

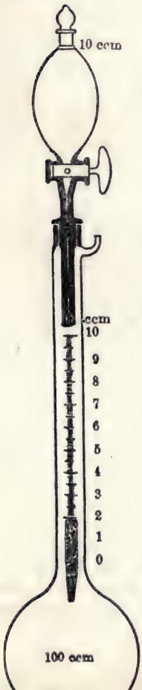
$$\frac{H_2O \times 11.190}{\text{weight of sample}} = \%\ \text{hydrogen}$$

## 16-B. DETERMINATION OF NITROGEN IN PETROLEUM OR ASPHALT. BY THE KJELDAHL METHOD.

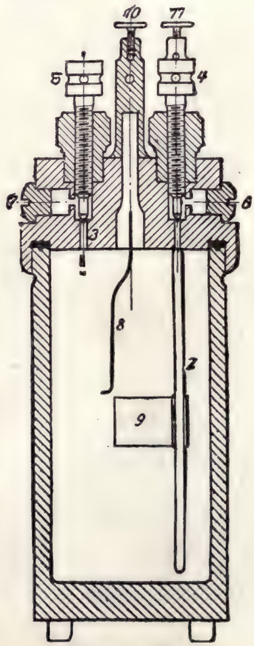
5 grams of the sample are weighed into a pyrex Kjedahl digesting flask. 50 cc. of the digestion mixture composed of concentrated sulphuric acid containing 20% of phosphorous pentoxide is added to the flask. About one-third gram of mercuric oxide is added and the contents of the flask are heated with a strong flame until the solution has become pale yellow or colorless. The digested material is now cooled, diluted with about 150 cc. of water and neutralized with strong



Parr Apparatus for Sulphur




Flask for Aromatics




Kroeker Bomb

caustic soda solution. Zinc shavings and some Potassium sulphide are added. The flask is quickly connected with the condenser tube and the ammonia is distilled off into a 25 cc. of N/10 sulphuric acid. The excess of acid is titrated with N/10 alkali. Each cubic centimeter of sulphuric acid consumed is equivalent to .001404 gram of nitrogen.

## 17. DOCTOR TEST FOR GASOLINE.

**Reagent.**

Sodium plumbite or "doctor" solution—Dissolve 125 grams of sodium hydroxide (NaOH) in a liter of distilled water. Add 70 grams of litharge (PbO) and shake vigorously for 15 or 30 minutes or let stand with occasional shaking for at least a day. Allow to settle and decant off the clear liquid. Filtration through a mat of asbestos may be employed if the solution does not settle clear. The solution should be kept in a bottle tightly stoppered.

**Test.**

Shake vigorously for about 15 seconds two volumes of gasoline and one volume of the "doctor" solution. Note color. A small pinch of flowers of sulphur should be added and the tube again shaken for 15 seconds and allowed to settle. The quantity of sulphur used should be such that practically all of the sulphur floats on the surface, separating the gasoline from the "doctor" solution.

**Interpretation.**

If the gasoline is discolored or if the sulphur film is so dark that its yellow color is noticeably masked, the test shall be reported as positive, and the gasoline condemned as "sour." If the liquid remains unchanged in color and if the sulphur film is bright yellow, or only slightly discolored with gray or flecked with black, the test shall be reported negative and the gasoline considered "sweet."

## 18-A. OLEFINS OR UNSATURATED HYDROCARBONS AND REFINING LOSS IN PETROLEUM PRODUCTS.

Use apparatus and equipment as shown on page 337.

**Method using a Babcock cream bottle.**

Weigh up a clean and dry 30% Babcock cream bottle, add to it exactly 5 cc. of the oil to be tested. Weigh again giving the amount of oil used. Cool in ice water and add 10 cc. of concentrated commercial sulphuric acid, letting the acid run down the sides of the bottle. Shake while cooling in the ice water. Keep stoppered with a rubber stopper. Let stand for ½ hour with occasional shaking and constant cooling. Add sufficient concentrated sulphuric acid (commercial) to bring the reading about to the top of the scale on the neck of the bottle. Centrifuge for five minutes in the No. 1 centrifuge with the resistance at the first notch from the left. This gives a speed of 1000 R. P. M. Keep the rubber stopper in while centrifuging so that there will be no evaporation. The stopper shall be large enough so that it is not forced into the bottle.

The reading on the neck of the bottle divided by 5 is the net amount of saturated hydrocarbons contained. This multiplied by 20 and take from 100 gives the per cent of unsaturated hydrocarbons. For great accuracy the oil may be corrected for specific gravity and temperature and for the amount adhering to the sides of the pipet in which case the weighings are used. The waste acid from the Bab-

cock bottle is poured into a bottle from which the sulphuric acid may be recovered by separating the oil and oxidising the organic material in the acid.

### 18-B. METHOD USING A 10 CC. GLASS STOPPERED CYLINDER. (Egloff.)

Use apparatus and equipment as shown on page 337.

Add exactly 5 cc. of the oil to be tested to the cylinder and 2 cc. of sulphuric acid of gravity 1.84. Shake thoroughly for about 5 minutes and place in centrifuge and centrifuge at the rate of 1000 R. P. M. for 5 minutes. The shrinkage of the oil in cubic centimeters $\times$ 20 is the percentage of olefins.

### 18-C. REFINING LOSS OF PETROLEUM PRODUCTS.

Use the color tube as shown on page 281.

To a 50 cc. color tube that is graduated in .1 cc. and glass stoppered, add 45.0 cc. of the oil. Add exactly 1 cc. of 66° Baume' sulphuric acid. Shake thoroughly for about 5 minutes. Set vertically in a rack for at least one hour and preferably over night. The increase in volume of the acid in the bottom of the tube x 2-2/9 is the refining loss.

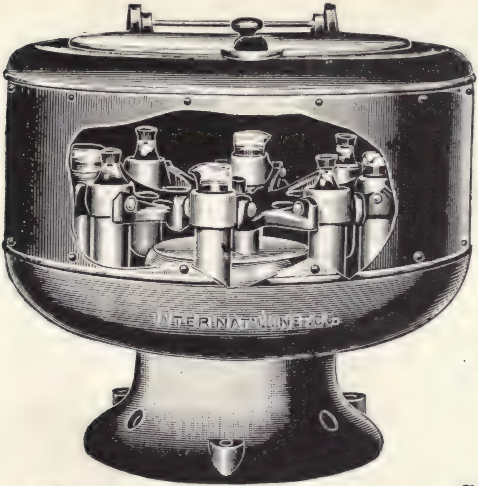
### 19-A. METHOD FOR DETERMINING AROMATIC AND PARAFFIN HYDROCARBONS IN PETROLEUM PRODUCTS.

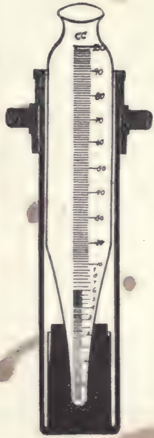
The apparatus is shown in the figure on page 334. The flask containing 30 cc. of fuming nitric acid (specific gravity 1.52) is cooled to —10°C by a salt ice freezing mixture. The separatory funnel is filled to the 10 cc. mark with the oil under test. The oil is ru drop by drop with continuous shaking into the cooled acid during period of not less than 45 minutes. With uncracked petroleun products 15 minutes is sufficient. The mixture is allowed to stanc 15 minutes after completion of the reaction and then enough nitri acid (ordinary concentrated) at —10° temperature is added to the contents of the flask until the oil under the surface is brought into the graduated neck. The volume is read when the neck is at room temperature, the body of the flask being in the freezing mixture. This volume represents the paraffin hydrocarbons.

The mixture is transferred to a separatory funnel, the lower layer run off into a 500 cc. measuring flask containing 150 cc. of water. The neck should be graduated for a 10 cc. portion into 1/10th cc. The temperature will rise in proportion to the amount of olefins and aromatics present and more or less oil will separate according to the amount of paraffin hydrocarbons present.

The unattacked oily layer in the separatory funnel is washed with water and then examined for specific gravity and boiling point. The aqueous layer of nitric acid is warmed for 15 minutes to dissolve as completely as possible the resinous substances formed. The cooled liquid is shaken with 100 cc. of ether, the aqueous layer separated and the ether layer again washed free from acid with water, then with a solution of caustic potash containing 50 grams of KCH in 500 cc. of water with 50 cc. of alcohol.

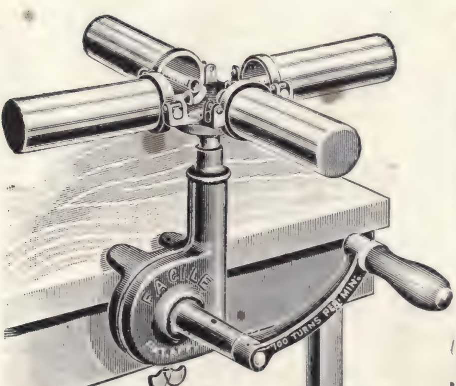
The caustic potash is drawn off and again the ether layer is washed with water. It is now dried with calcium chloride, filtered, the ether evaporated and the residue weighed. The residue consists of reddish brown oil, aromatic nitro-derivatives. The weight divided by 1.15 gives the percentage of aromatic hydrocarbons.





Good type of electric centrifuge.

Centrifuge tube for water and "B.S. or sediment.




Hand Centrifuge

Olefin Tubes

The difference between the aromatic and cyclic hydrocarbons and the paraffin hydrocarbons and 100% is the amount of olefins. This may be checked by direct determination as shown under olefins.

### 19-B. SHORT METHOD FOR AROMATIC AND CYCLIC HYDROCARBONS.

Distillation of 800 cc. of the hydrocarbons under examination may be made in a 1 liter distilling flask in accordance with the apparatus set forth on page 310. Cuts may be made at 95°, 120° and 150°C and the percentage of aromatic compounds calculated from the specific gravity using the following specific gravities as the basis:

| Temperature of Cut | Specific Gravity of Aromatic Hydrocarbon | Specific Gravity of Non-Aromatic Hydrocarbon |
|---|---|---|
| 95°C | 0.880 | 0.720 |
| 120°C | 0.871 | 0.730 |
| 150°C | 0.869 | 0.760 |

This is in accordance with the Bulletin No. 114 of the Bureau of Mines, page 95.

### 20. FREE ACID IN LUBRICATING AND OTHER PETROLEUM OILS.

Weigh 10 grams of the oil into an Erlenmeyer flask. Add 50 cc. of 95% denatured alcohol which has been previously neutralized with dilute caustic soda. Heat over a gauze to the boiling point. Shake thoroughly to dissolve the acid. Titrate while hot with N/10 caustic soda using phenolphthalein as indicator shaking thoroughly after each addition of NaOH, continuing to the first persistent pink color. Express results in terms of oleic acid. 1 cc. of N/10 NaOH = 0.0292 gm. of oleic acid.

### 21. FLOC TEST.

Take a hemispherical iron dish and place a small layer of sand in the bottom. Take a 500 cc. Florence or Erlenmeyer flask and into it put 300 cc. of the oil (after filtering if it contains suspended matter). Suspend a thermometer in the oil by means of a cork slotted on the side. Place flask containing the oil in the sand bath and heat bath so that the oil has reached a temperature of 240°F at the end of one hour. Hold oil at temperature of not less than 240°F nor more than 250°F for six hours. The oil may become discolored but there should be no suspended matter formed in the oil. The flask should be given a slight rotary motion and if there is a trace of floc, it can be seen to rise from the center of the bottom.

### 22. CORROSION AND GUMMING TEST OF GASOLINE AND NAPHTHA.

The gasoline when subjected to the corrosion test shall show no black corrosion and no weighable amount of gum.

Directions for making test:

The apparatus used in this test consists of a freshly polished hemispherical dish of spun copper, approximately 3½ inches in diameter.

Fill this dish within ⅜ths inch of the top with the gasoline to be examined and place the dish upon a steam bath. Leave the dish on the steam bath until all volatile portions have disappeared.

If the gasoline contains any dissolved elementary sulphur the bottom of the dish will be blackened.

If the gasoline contains undesirable gum-forming constituents there will be a weighable amount of gum deposited on the dish. Acid residues will show as gum in this test.

## 23. PENETRATION OF PETROLEUM ASPHALTS AND OTHER BITUMINOUS MATERIALS.

The apparatus used for this test is that shown on page 340.

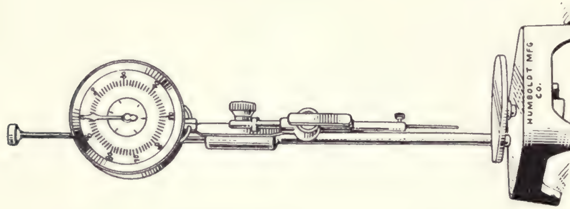
The penetration is the consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature. When the conditions of test are not specifically mentioned the load, time and temperature are understood to be 100 grams, 5 seconds, 25°C (77°F) respectively and the units of penetration indicate hundredths of a centimeter. The container for holding the material to be tested should be a flat bottomed cylindrical dish 2 3/16 inches in diameter and 1⅜ inches deep or the American Can Co. Gill style ointment box, deep pattern, 3 ounce capacity.

The needle is a cylindrical steel rod 2 inches long and with a diameter of 0.04 inch and turned on one end to a sharp point having a taper of ¼-inch. The bath for the sample and the penetrometer should hold at least 10 liters of water. The sample should be melted at the lowest possible temperature and stirred until it is homogeneous and free from air bubbles. It is then poured into the sample container to a depth of about ¾-inch and is allowed to cool for one hour in the air. It is now placed in the water bath maintained within 0.1°C of the temperature of penetration for one hour.

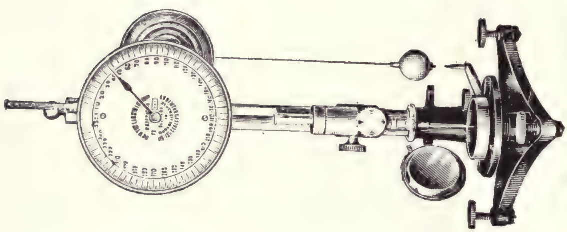
In making the test, the sample is immersed in water and the needle loaded with the specified weight is adjusted to make contact with the surface of the sample. This may be accomplished by making contact of the actual needle point with its image reflected by the surface of the sample or contact may be meted by slightly turning the container so that a faint scratch on the surface of the bitumen is observed. The needle is then released for the specified time and the distance measured by the means provided with the machine. At least three tests shall be made at different points on the surface of the sample and after each test the needle shall be wiped clean of all bituminous matter. The reported penetration is the average of at least three tests whose values do not differ more than four points between the maximum and minimum. Other conditions for penetrations particularly for oil asphalt filler and roofing material shall be the following:

At 0°C (32°F) 200 grams weight 60 seconds.

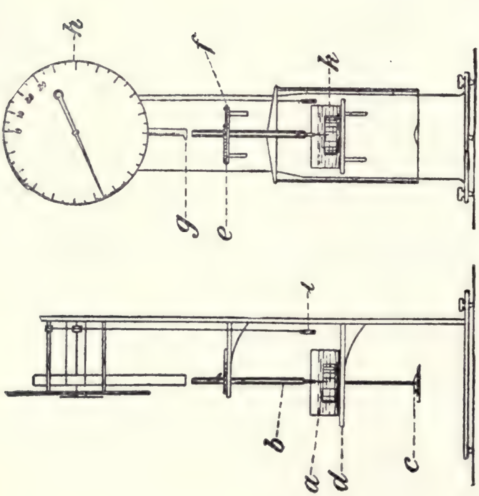
At 46.1°C (115°F) 50 gram weight 5 seconds.




Humboldt Penetrometer



N. Y. T. L. Penetrometer



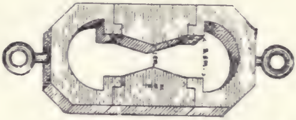

—Dow Penetration Machine.

## 24. DUCTILITY OF SEMI-SOLID BITUMINOUS MATERIALS.

The apparatus used for this test is shown on page 342.

It consists of a machine for uniformly pulling a cylinder or briquet of the asphaltic cement at a slow rate of speed until it breaks. Two types of molds for the sample are used, one is a square mold having a cross section of 1 sq. cm. at its narrowest point, the other is a round mold separated by a cylindrical section of 1 cm. diameter. Either mold is used on the same machine.

The asphalt is carefully melted as in the penetration test and the mold is completely filled so that it bulges at the top enough to allow for shrinkage. The brass is amalgamated with mercury to prevent sticking. The temperature at which the test is made should correspond to that temperature at which the sample being tested has a penetration of 50°. The rate of pulling may be either the slow rate of 5 cm. per minute or the fast rate of 60 cm. per minute, the machine being adapted for either speed. The pulling is continued until the thread of asphalt breaks. The distance that it has been drawn out without breaking, expressed in centimeters is the ductility. By the square mold ductility a result is obtained which is about 3½ times that of the round ductility.



Square Ductility Mold

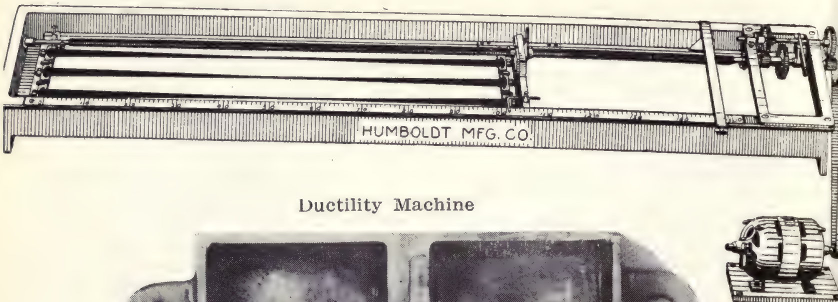
## 25. LOSS ON HEATING OF OIL AND ASPHALTIC COMPOUNDS.

The loss in weight by oil and asphaltic compounds when they are heated in an oven at a temperature of 163°C (325°F) is determined on 50 grams of the water free substance contained in a flat bottomed dish, the inside dimensions of which are approximately 2 3/16 inches in diameter and 1⅜ inches deep (this is the 3 ounce Gill style ointment box, deep pattern).

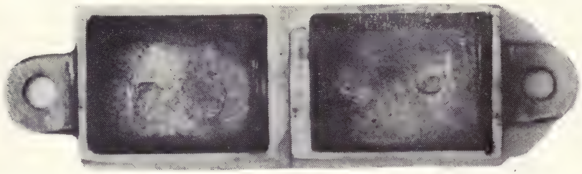
The oven in which the substance is to be heated is brought to temperature before the sample is introduced and the temperature of the sample under test shall be regarded as that of a similar quantity of the same material immediately adjoining it in the oven in which the bulb of a standardized thermometer is immersed. The oven may be any well constructed type either circular or rectangular and the source of heat may be either gas or electricity. The samples under test rest in the same relative position in a single row upon a perforated shelf 9.75 inches in diameter as shown on page 343. A good type of oven is also shown on same page. The shelf is suspended by a vertical shaft midway in the oven which is revolved by mechanical means at the rate of from 5 to 6 R. P. M.

## 26. ASPHALT IN OIL AND ASPHALTIC COMPOUNDS.

50 grams of the crude oil, fuel oil, lubricating oil, road oil or other material are weighed into a 3 ounce Gill style ointment box, deep pattern, and placed in an oven heated either by electricity or gas and with good circulation to a temperature of approximately 500°F. Heat is maintained until the consistency of the residue is such that at a temperature of 77°F it has a penetration of 100. The amount of asphalt is reported in terms of the 100° penetration material.




Ductility Machine



Round Ductility Mold

## 27-A. ASPHALTENES IN OIL AND ASPHALTIC PRODUCTS (SOLUBILITY IN PETROLEUM NAPHTHA).

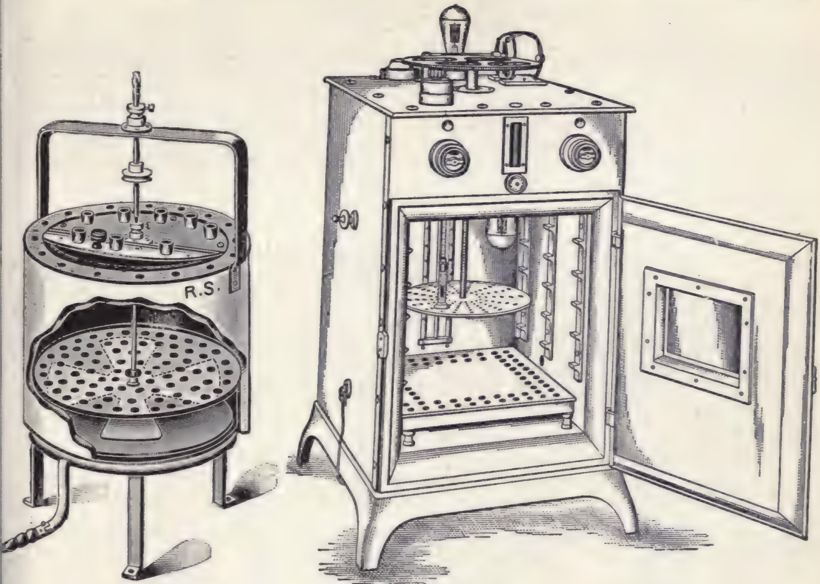
Weigh up one gram of the oil or asphaltic material into a 150 cc. Erlenmeyer flask. Add exactly 100 cc. of paraffin base petroleum naphtha of a gravity of 38°Be′. Shake until the material is well disintegrated and allow to stand for at least 5 hours and preferably over night, the flask being tightly corked. Prepare a Gooch crucible having a uniform layer of asbestos fiber in the bottom about ⅛-inch thick. Dry and ignite the prepared crucible. Place the crucible in a vacuum filter as shown in the figure on page 346 and pour the petroleum naphtha solution of the material through it. Drain the Erlenmeyer flask as thoroughly as possible and rinse out with 100 cc. of 88°Be′ petroleum naphtha so that the last of the naphtha is not stained with the bituminous material. Care must be taken to prevent undue disturbance of the asbestos mat. Draw air through the residue on the Gooch crucible for a minute with a suction pump and place it in the drying oven at 105°C for ½ hour. Weigh, ignite and weigh again. The difference between the two weighings is the asphaltene. This taken from the original may also be recorded as the solubility in petroleum ether.

## 27-B. SOLUBILITY IN CARBON BISULPHIDE. (TOTAL BITUMEN.)

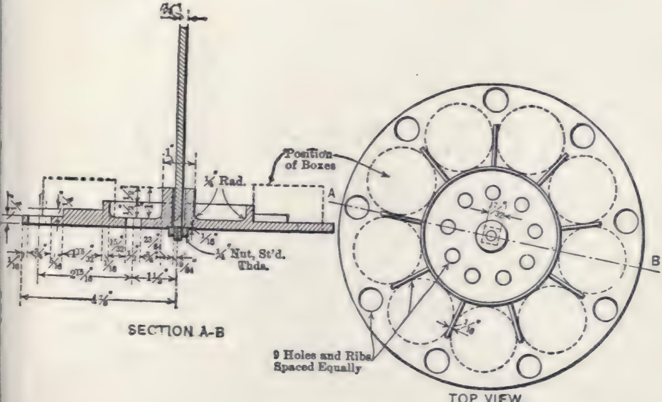
This test is performed in the same way as for asphaltenes or solubility in petroleum naphtha except that a 5-gram sample is preferably used. The same apparatus is used.

## 27-C.—SOLUBILITY IN CARBON TETRACHLORIDE.

This test is performed in exactly the same manner as with carbon bisulphide except that the flask containing the carbon tetrachloride must be kept in a dark place. The difference between the solubility in carbon bisulphide and carbon tetrachloride represents the CARBENES.




Gas oven Electric oven
Ovens for determination of loss on heating at 325°F.




Detail of shelf used in loss test.

## 28. RESISTANCE OF ASPHALTIC CEMENT TO OXIDATION.

After being subjected to the following tests the film of asphalt should be brilliant and lustrous, should not be scaly and fragile, should adhere firmly to the metal and should not be dull and cheesy in texture.

A strip of thin sheet iron 2 inches wide and 6 inches long is covered on its lower 4 inches with the melted asphaltic cement. This strip is placed in an oven at 275°F for 15 minutes and allowed to thoroughly drain.

It is removed from the oven and allowed to cool, then placed in an electrically heated oven at a temperature of 450°F for one hour. At the end of the hour, the door of the oven is opened and the heat is turned off, the specimen being allowed to remain in the oven.

The oven shall be one having an outside diameter of 12x12x12 inches with an opening in the top 1 cm. in diameter, the heating elements being in the bottom of the oven. The resistance shall be so distributed that the heat is uniform throughout the oven. The lower end of the strip shall be suspended so that it is at least 3 cm. from the bottom of the oven.

The resistance is preferably so arranged that three different heats can be maintained with a snap switch such that the lowest heat is 325°F, the medium heat is 400°F and the highest heat is 450°F.

## 29. PARAFFIN WAX OR SCALE IN PETROLEUM AND BITUMINOUS PRODUCTS.

The apparatus used is shown on page 347.

Instead of the metal retort, a glass distilling flask with a glass air condenser may be used if desired. 100 grams of the oil, bitumen or material under examination are weighed into the retort and distilled as rapidly as possible to dry coke. The distillate is caught in a 150 cc. Erlenmeyer flask, the weight of which has been previously ascertained. During the early stages of distillation a cold, damp towel wrapped around the stem of the retort will serve to condense the distillate. After high temperatures have been reached, this towel may be removed. When the distillation is completed, the distillate is allowed to cool to room temperature and is then weighed in the flask. This weight minus that of the flask gives the weight of the total distillate.

Five grams of the well mixed distillate is then weighed into a 100 cc. Erlenmeyer flask and mixed with 25 cc. of Squibb's ether. 25 cc. of Squibb's absolute alcohol is then added, after which the flask is packed closely in a freezing mixture of finely crushed ice and salt maintained at —18°C in a quart tin cup. After remaining 30 minutes in this mixture, the solution is quickly filtered through a No. 575 C. S. & S. 9 cm. hardened filter paper placed in a glass funnel which is packed in a freezing mixture as shown in figure. Vacuum should be employed to hasten filtration. The freezing-mixture reservoir shown in the figure may be made by cutting in half a round glass bottle measuring approximately 120 millimeters in diameter and using the upper half in an inverted position. Any precipitate remaining on the paper should be washed until free from oil with about 50 cc. of a 1 to 1 mixture of Squibb's ether and absolute alcohol cooled to —18°C.

After the paper has been sucked dry, it should be removed from the funnel and the adhering paraffin scale should be scraped off into

a weighed crystallizing dish and dried on a steam bath. The dish and contents should then be cooled in a dessicator and weighed.

The weight of the paraffin scale so obtained, divided by the weight of the distillate taken and multiplied by the percentage of the total distillate obtained from the original sample, equals the percentage of the paraffin scale.

## 30-A. BITUMEN AND GRADING OF ASPHALT SURFACE MIXTURE.

The asphaltic surface is softened by warming and is thoroughly mixed. 100.0 grams are weighed into a thin porcelain dish. This is placed in a gas or electric muffle, as shown on page 348, and heated with good aeration at a temperature not exceeding 700°C, preferably about 500°C, or at a barely perceptible red heat.

It is well to use a pyrometer in the muffle. Usually about two hours is required for the complete combustion of the carbonaceous material. The dish and contents are now removed from the muffle, allowed to cool and weighed. The loss in weight is the percentage of bitumen. The mineral matter is now screened through a nest of screens containing the 1, 2, 4, 10, 20, 40, 80, 200 meshes to the lineal inch. The amount passing each screen and retained on the next is recorded. The exact description of the sizes is as follows:

| Mesh | Opening in Inches | Opening in Millimeters | Diameter of Wire, Inch |
|---|---|---|---|
| 1 | 1.050 | 26.67 | 0.149 |
| 2 | 0.525 | 13.33 | 0.105 |
| 4 | 0.1850 | 4.699 | 0.065 |
| 10 | 0.0650 | 1.651 | 0.035 |
| 20 | 0.0340 | 0.864 | 0.016 |
| 40 | 0.0150 | 0.381 | 0.010 |
| 80 | 0.0068 | 0.173 | 0.00575 |
| 200 | 0.0029 | 0.074 | 0.0021 |

## 30-B. BITUMEN AND GRADING OF ASPHALTIC SURFACE MIXTURE BY EXTRACTION.

The bituminous mixture should be warmed until it may be readily broken apart by hand, without fracturing any of the stony particles.

Five hundred grams of the disintegrated mixture should be packed as tightly as possible in the wire basket and then covered with a disc of cotton or felt of one-quarter inch to one-half inch thickness.

One hundred and seventy-five to two hundred cc. of carbon disulphide, carbon tetrachloride, chloroform, or benzole is placed in the inside vessel in which the wire basket is suspended.

Cool water should be circulated through the inverted cone condenser, which is also the cover of the apparatus, and is not intended to fit tight.

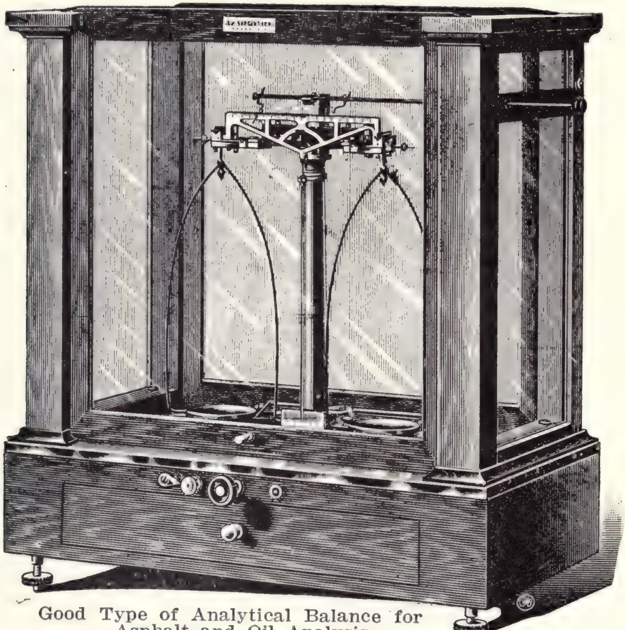
A 16 c. p. carbon filament incandescent lamp is the source of heat.

A 500-gram sample of mixture should extract clean with carbon disulphide in about three hours. From 200 to 300 grams of asphalt block or Topeka type mixture is a sufficiently large sample for that type of mixture.

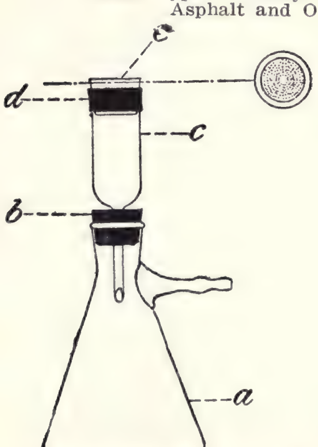
After extraction, the solvent and matter removed from the sample during the analysis should be burnt to recover any fine mineral particles which may have passed into the extract.

This method has the advantage of giving the true soluble bitumen

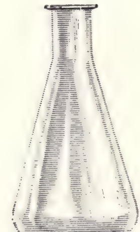
and of leaving the mineral matter in such condition that it is more easily screened. However, it has the disadvantage of requiring a longer time, a considerable amount of solvent and of giving slightly higher results in percentage of bitumen unless the extracted matter is burned out. Extraction may also be made by the Rotarex centrifuge.



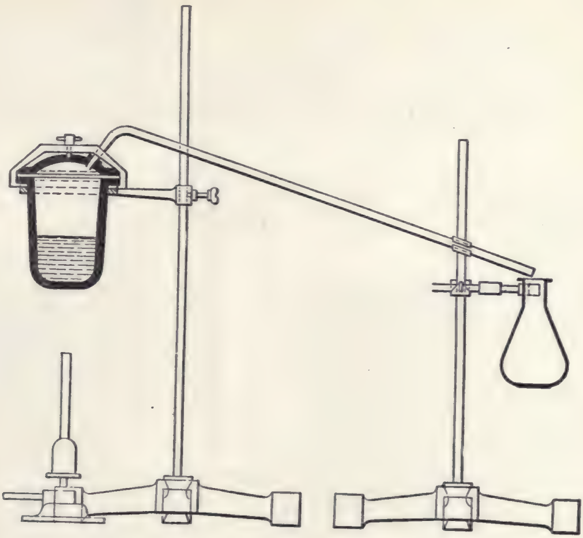
Good Type of Analytical Balance for Asphalt and Oil Analysis



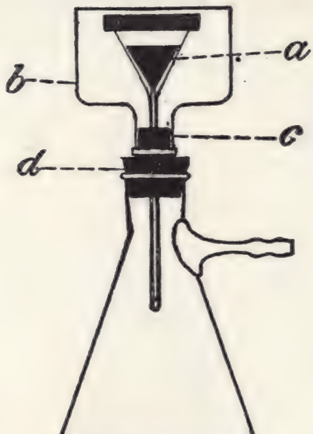

Suction Flask For Solubility Tests



Erlenmeyer Flask



Paraffin Scale Distillation

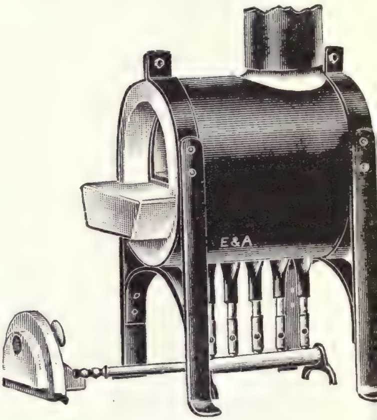



Paraffin Filter Flask

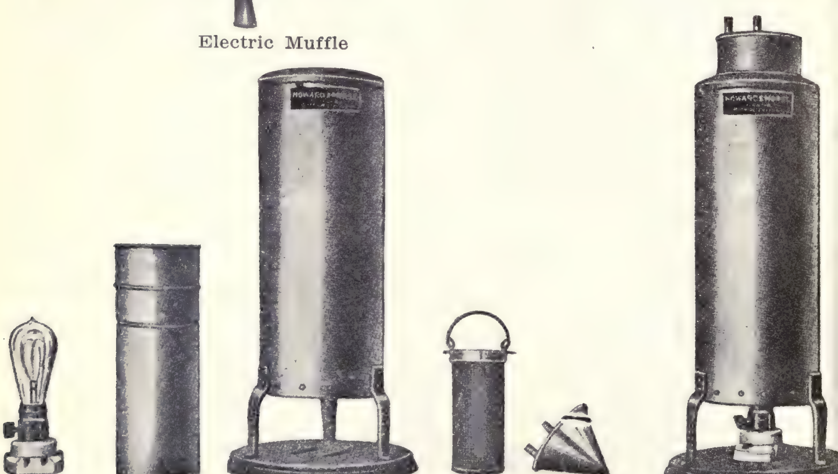
## 31. TENSILE STRENGTH OF BITUMINOUS SURFACE MIXTURE.

The surface mixture to be tested is heated to over 240°F to soften it and is thoroughly compressed into a standard cement testing briquet mold. The mold is then packed in ice for at least two hours. It is now quickly put in the tensile strength machine used for testing portland cement and pulled until it fails. Good bituminous surface mixture will give a tensile strength of as high as 600 lbs. per sq. in. Poorly cemented material will give a tensile strength usually lower than 200 lb. per sq. in.

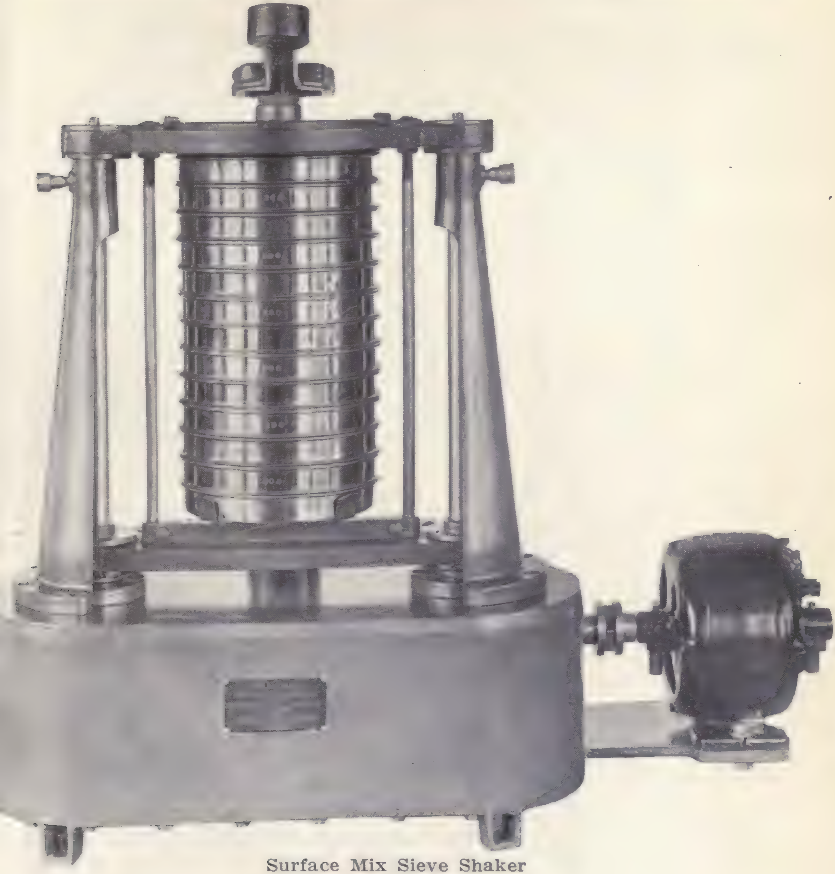
Electric Muffle



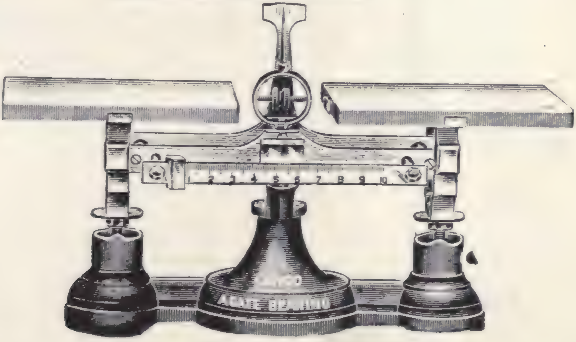

Gas Muffle



N. Y. T. L. Surface Mix Extractor.

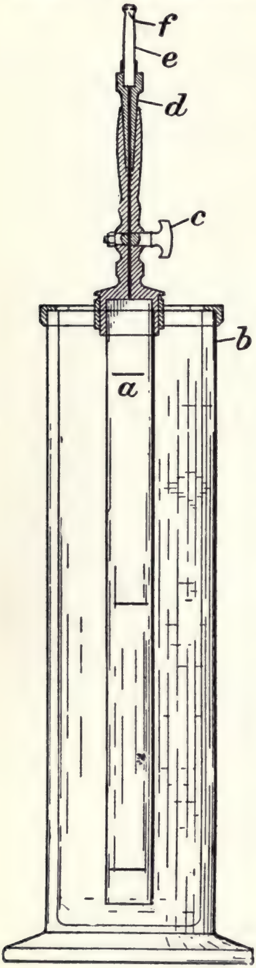


Surface Mix Sieve Shaker



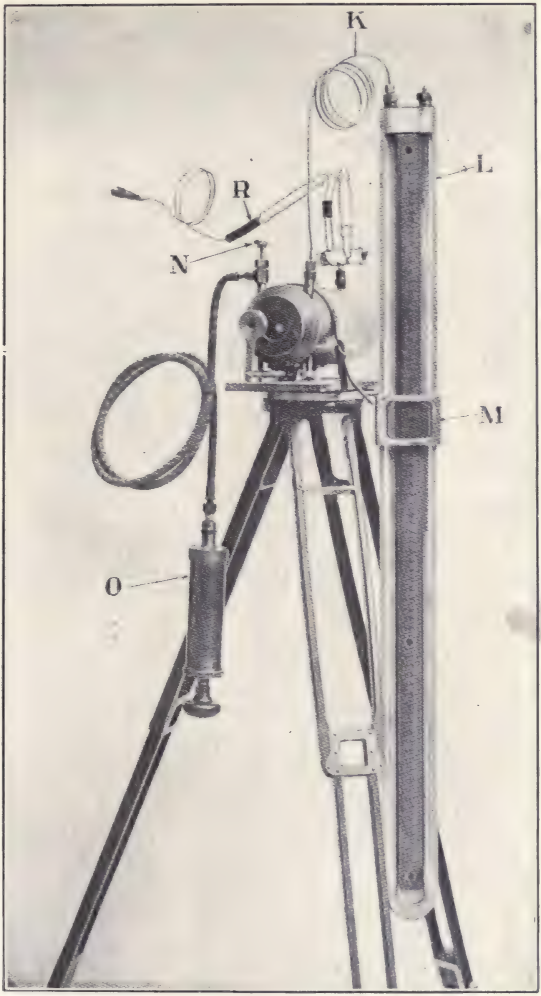

Mineral Aggregate Grading Balance

## 32-A. DETERMINATION OF SPECIFIC GRAVITY OF GAS.




The apparatus consists of a glass jar, b, with a metal top into which fits a brass column having suspended from its base a long, graduated tube, a, and at its top a cock, c, and a ground-joint socket d, into which sets a socket holding a small glass tip, e, closed at the top with a thin piece of platinum, f. In this platinum is a minute hole to permit the passage of gas or air at a very slow rate. All the metal parts are nickeled. The mode of operation is as follows: The glass jar is filled with water to the top graduation mark of the tube or to a point a little above it. The tube is then withdrawn so that it may be filled with air. The cock on the standard is then closed and the tube is replaced with air. The cock is then opened, and the number of seconds required for the water to pass from the lowest graduation mark to the graduation mark above it is recorded with a stop watch. The tube is then withdrawn and filled with gas and the procedure repeated. The specific gravity (air=1) is obtained by dividing the gas time squared by the air time squared. Thus, if A represents the time required for the gas to pass through the orifice, and B represents the time required for the air to pass through the orifice, the **specific gravity** of the gas will be represented by

$$\left\{\frac{A}{B}\right\}^2$$




Edwards Gas Balance

## 32-B. SPECIFIC GRAVITY OF GAS BY THE EDWARDS GAS BALANCE.

Above, the figure shows the Edwards Gas Balance completely assembled with mercury manometer "L" at the right in the foreground, hand pump "O" at the left for evacuating the balance chamber, and connection "R" to the gas sample by means of the stop cock on the back end of the balance chamber. On page 353 is shown the balance beam consisting of an air tight bulb of spun brass,

counter-weighted with adjustable balancing weights. The bearing points are also adjustable, allowing the center of gravity of the beam to be raised or lowered, thus providing a control of the sensibility. The needle points rest on glass bearings.

The beam is adjusted so that it will come to equilibrium in atmosphere with the counter-weight end slightly below a horizontal plane through the bearing points. In this position a partial vacuum is required to bring it to a level position which position is effected by bringing into alignment the cross hair mounted permanently on glass and the line on the end of the balance beam. The air that is allowed into the chamber when making this balance must be drawn through some drying agent assuring dry air. The vacuum reading is then observed on the "U" gauge. This should be repeated and checked. The balancing chamber is then purged of air and the gas allowed to fill it to a pressure sufficient to bring the beam to the same position of equilibrium again. The pressure is then observed on the "U" gauge. These pressures are then reduced to absolute pressure, knowing the barometric pressure at the time of making the test. The specific gravity of the gas is the quotient of the absolute air pressure divided by the absolute gas pressure. (Air=1.000.)

a = Barometric pressure.
b = Balancing pressure air.
c = Balancing pressure gas.

$$\text{Specific gravity} = \frac{a\text{-}b}{a\text{-}c}$$

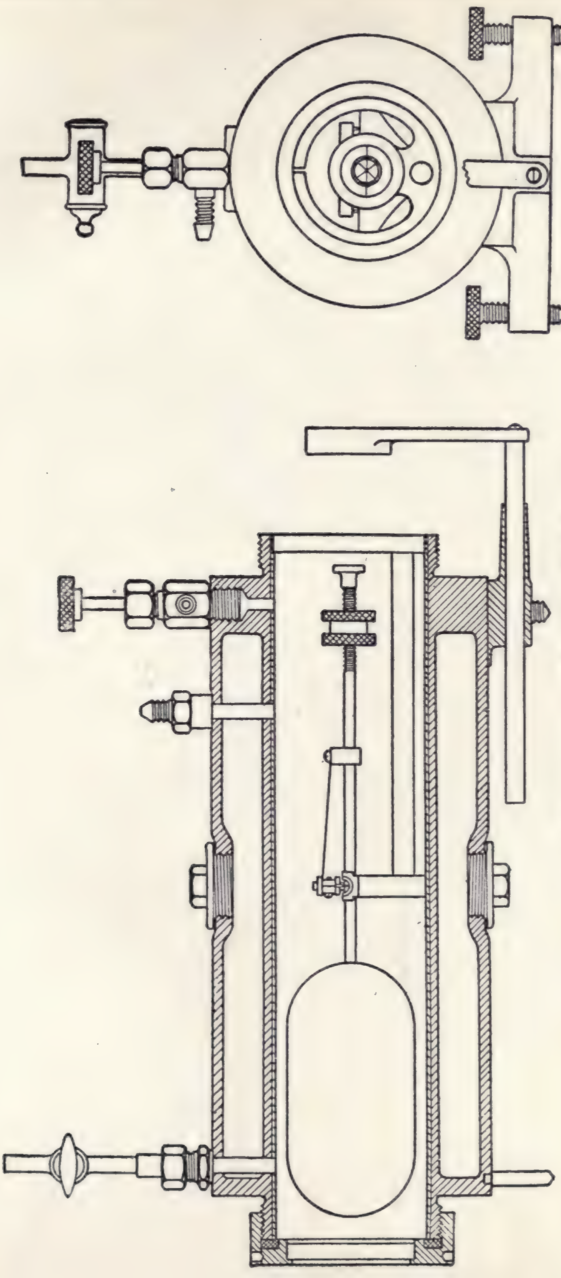
When air is present in gas it is determined with an Orsat apparatus, or other convenient apparatus. The correction of the observed specific gravity to the actual specific gravity is made with following formula:

$$g = \frac{100\ d - a}{100 \quad - a}$$

a = % air.
d = determined or observed specific gravity.
g = actual specific gravity.

Example:—

| | | |
|---|---|---|
| Barometric pressure (millimeters) | | 756.4 |
| Gage readings with air (millimeters) | 396.7<br>390.3 | |
| Pressure (milimeters) | | —6.4 |
| Total pressure (millimeters | | 750.0 |
| Gage readings with gas (millimeters) | 189.3<br>597.4 | |
| Pressure (millimeters) | | +408.1 |
| Total Pressure (millimeters) | | 1164.5 |
| Specific gravity | $\frac{750.0}{1164.5}$ =0.6441 | |



Construction of Edwards Gas Balance

## 33-A. ABSORPTION METHOD FOR TESTING NATURAL AND CASINGHEAD GAS.

Fill the two-armed pipet commonly known as the Hofman apparatus with distilled water. The glass stop cock at the top of the closed graduated arm is a two-way cock, so that the tube above the stop cock can be completely cleared of air. The end of the stop cock through which the outside discharge takes place is closed with a rubber tube and pinch cock. A funnel is set on top of the tube, water is introduced and the tube is washed out with distilled water. The pinch cock is closed, the funnel is removed and the gas is introduced in the usual manner by displacement with water until about 50 cc. are in the graduated arm. The level of the water is made the same in the two arms and the reading of the quantity of gas is made after it has adjusted itself to the room temperature.

25 cc. of Claroline oil or straw oil are introduced into the open arm. The open arm is now stoppered or held with the thumb so that no air can gain access and the oil is shaken over into the other arm so that it overlies the water. The water is now withdrawn through the stop cock at the lower end of the U. The arm is now filled and kept filled with Claroline or straw oil shaking until the gas ceases to be absorbed. The absorption is calculated in percentage.

The amount of gasoline that may be obtained by absorption from the gas may be approximately calculated from the following table:

**Casinghead Gas Yield.**

| Absorption Percentage | Yield of Gasoline Gallons per 1000 Cu. Ft. of Gas |
|---|---|
| 25 | .50 |
| 30 | .75 |
| 35 | 1.50 |
| 40 | 2.00 |
| 50 | 2.50 |
| 60 | 3.50 |
| 80 | 5.00 |

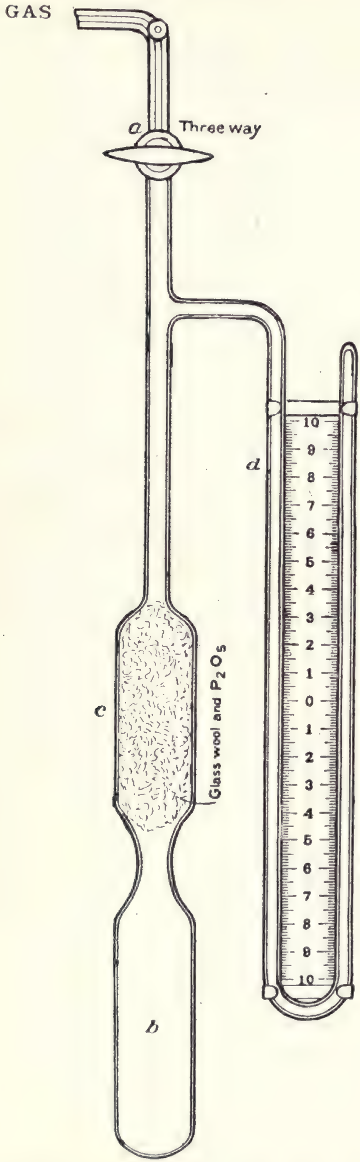
One gallon of gasoline obtained from 1000 cu. ft. of gas reduces the volume about 25 to 30 cu. ft. and reduces the heating value about 75 to 100 B. T. U. per cu. ft. or 7½ to 10%. One gallon of gasoline at 20c a gallon would then extract .6c from the value of gas at 20c per 1000 cu. ft. About one-half of the natural gas of the United States contains gasoline in commercially obtainable quantity. Some casinghead gas such as at Sisterville, West Va., gives 13 gallons of gasoline per 1000 cu. ft. and has a heating value of 2500 B. T. U. per cu. ft. Shellac is the best thread dressing material for gasoline and oil joints since it is not soluble in gasoline nor water.

## 33-B. FREEZING METHOD FOR TESTING NATURAL GAS FOR GASOLINE CONTENT.

This method is from Technical Paper 104, Bureau of Mines, page 26. The sample of natural gas or casinghead gas is introduced in the usual manner into the apparatus shown on page 356.

In this apparatus (a) is a three-way stop cock, (c) is a tube filled with glass wool and phosphorus pentoxide for the purpose of drying, (b) is a portion of tube which is introduced into liquid air, (d) is a manometer tube containing mercury and is closed at the further end.

In filling the manometer, the apparatus must be completely exhausted of its air. Sufficient mercury is introduced so that its level rests at the zero point of the scale when under a vacuum. The three-way stop cock at (a) connects to the vacuum pump and to the gas sample container. The sample of gas is drawn in at ordinary atmospheric pressure and the stop cock (a) is closed and the bulb (b) is introduced into the cooling medium. The temperature below 100°C is taken. At this temperature all of the gasoline constituents are completely liquefied. While maintained at this low temperature, the vapor above the liquefied gasoline is exhausted with the vacuum pump thus removing the non-condensible gas. The bulb is now taken out of the refrigerant and allowed to warm up to the temperature at the beginning of the test. The mercury level in the manometer is read, the pressure indicated being the partial pressure of the gasoline in the sample before the dry gas had been removed. The percentage by volume of gasoline vapor is $\frac{100\,a}{b}$, a being the partial pressure of the gasoline vapor after the test, b being the original atmospheric pressure of the sample. The percentage of gasoline vapor gives the number of pints of gasoline that may be expected in the manufacture of gasoline from the gas under test by the absorption process.




Freezing Method for Gasoline in Gas.

## 34. COMPLETE ANALYSIS OF GAS.

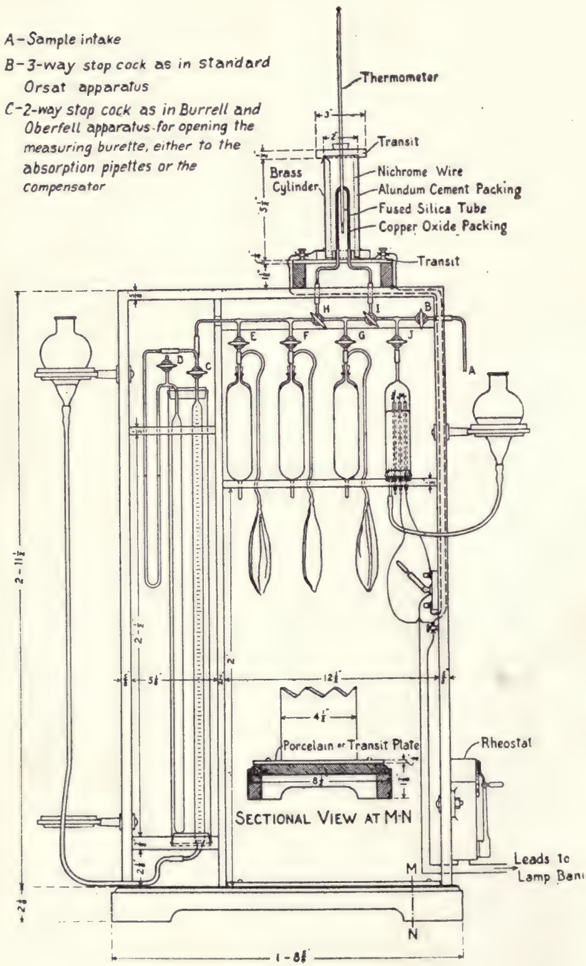
This apparatus is that described in the Journal of Industrial & Engineering Chemistry by G. A. Burrell and G. G. Oberfell, Vol. 8, page 229.

It is designed for the analysis of a gas mixture containing carbon dioxide, unsaturated hydrocarbons, principally ethylene, oxygen, carbon monoxide, methane, ethane, hydrogen and nitrogen.

In the analysis the capillary train and U tube are swept free of gases by drawing a sample of air into the buret and passing it into the alkaline pyrogallate pipet G to remove oxygen. The residual nitrogen is then passed into all the pipets and through the CuO tube to sweep out other gases that may have been contained therein. The electric current is now turned on the electric heating oven, the temperature having been established by previous experiments. About a 100 watt furnace is required. The temperature desired is between 275 and 300°C. Some of the gas mixture is now drawn into the buret, measured and passed into the pipets E, F and G for the removal respectively of carbon dioxide, illuminants, and oxygen. After these constitutents have been removed the stop cocks H, I and J are turned so that communication is made between the buret and the pipet corresponding to J and through the CuO tube. The gas mixture is passed back and forth through the tube furnace until no further diminution in volume is noted by reading the gas volume in the buret. 15 minutes is usually required, the carbon monoxide being converted to carbon dioxide and the hydrogen to $H_2O$. The CO burns more rapidly if any hydrogen is present. When the gas is cooled and no further contraction takes place the remaining volume is read in the buret. The carbon dioxide is now removed by placing the gas mixture into the KOH pipet E. After the hydrogen and carbon monoxide have been determined the residual gas is placed in the KOH pipet for storage and the stop cock is closed. Enough oxygen to burn the paraffin hydrocarbons is then drawn into the buret, measured and passed into the slow combustion pipet J and the platinum spiral is heated to almost white heat. The residual gas is now withdrawn from the pipet E into the buret and from there slowly passed at the rate of not more than 10 cc. per minute into the pipet J. While operating it is well to cover the slow combustion pipet with gauze as occasionally if the gas is passed in too rapidly an explosion takes place. After combustion is complete, the contraction and the carbon dioxide are measured and the gas again passed into the slow combustion pipet and burned again. A small amount of further contraction may take place but may be ignored unless excessive.

For calculation of results the following example and formulae are useful:

(Continued on page 359.)




Burrell-Orsat Apparatus.

**Analysis of Gas From Pressure Stills.**

| | | |
|---|---|---|
| a. | Volume of sample taken | 44.1 cc |
| b. | Volume after KOH absorption | 44.0 cc |
| c. | **Carbon Dioxide — $CO_2$** | 0.1 cc = 0.22% |
| d. | Volume after $Br_2$ or Oleum absorption | 39.4 cc |
| e. | **Olefins or illuminants** | 4.6 cc = 10.43% |
| f. | Volume after alkaline pyrogallate absorption | 39.3 cc |
| g. | **Oxygen, $O_2$** | 0.1 cc = 0.22% |
| h. | Volume after burning in CuO | 35.2 cc |
| i. | **Hydrogen, $H_2$** | 4.1 cc = 9.30% |
| j. | Volume after absorption in KOH | 35.0 cc |
| k. | **Carbon Monoxide CO** | 0.2 cc = 0.45% |
| l. | Volume taken for slow combustion | 17.5 cc |
| m. | Oxygen added | 75.6 cc |
| n. | Total volume | 93.1 cc |
| o. | Volume after burning | 61.5 cc |
| p. | Contraction from burning | 32.6 cc |
| q. | Volume after KOH absorption | 45.0 cc |
| r. | Contraction from $CO_2$ | 16.5 cc |
| s. | **Methane** in sample | 16.0 cc = 72.56% |
| t. | **Ethane** in sample | 0.3 cc = 1.36% |
| u. | **Nitrogen** in sample | 1.2 cc = 5.46% |

To calculate amount of methane in the sample from the contraction from burning, "p," and the absorption with KOH, "r," use the following formulae:

$$\text{Methane (s)} = \frac{4p - 5r}{3}$$

$$\text{Ethane (t)} = \frac{4r - 2p}{3}$$

or to obtain % in original gas

$$\%\ \text{Methane} = \frac{100\ js}{al}$$

$$\%\ \text{Ethane} = \frac{100\ jt}{al}$$

$$\%\ \text{Nitrogen} = \frac{100\ ju}{al}$$

## REAGENTS USED IN GAS ANALYSIS.

**(1) Potassium Hydroxide.**

(a) For carbon dioxide determination.

500 grams of commercial potassium hydroxide are dissolved in 1 liter of distilled water. 1 cc. of this solution absorbs 40 cc. of $CO_2$.

(b) For the preparation of potassium pyrogallate for oxygen testing.

120 grams of potassium hydrate are dissolved in 100 cc. of water. 5 grams of crystalline pyrogallic acid are used with 100 cc. of this solution.

**(2) Potassium Pyrogallate.**

This solution is prepared when used except for charging absorption pipet. Five grams mixed with 100 cc. of potassium hydrate (b) gives a solution in which 1 cc. absorbs 2 cc. of oxygen.

**(3) Sodium Hydroxide.**

One hundred grams are dissolved in 300 grams of water and may be used instead of potassium hydrate where given above.

**(4) Cuprous Chloride.**

Method of preparation is to place a layer of copper oxide about ⅜ inch deep in the bottom of a two-liter acid bottle. Add an excess of long pieces of heavy copper wire reaching from the top to the bottom of the bottle and fill the bottle with hydrochloric acid of about 1.10 specific gravity. The absorption capacity of this reagent is 4 cc. of carbon monoxide CO for each 1 cc. of reagent. Metallic copper must always be maintained with the reagent to keep it in good condition.

**(5) Ammoniacal Cuprous Chloride.**

The acid cuprous chloride as prepared above is treated with ammonia until a faint odor of ammonia is perceptible. Likewise an excess of copper wire is maintained. The absorption capacity is 1 cc. of CO to 1 cc. of reagent.

**(6) Sodium Hypobromite.**

This is made of two solutions, one containing 100 grams of caustic soda with 250 cc. of distilled water, making 284 cc. of solution. The other, 25 grams of liquid bromine, 25 grams of potassium bromine and 200 cc. of water. The two solutions are not mixed until ready to use when equal parts are mixed. This reagent is very good for the determination of illuminants.

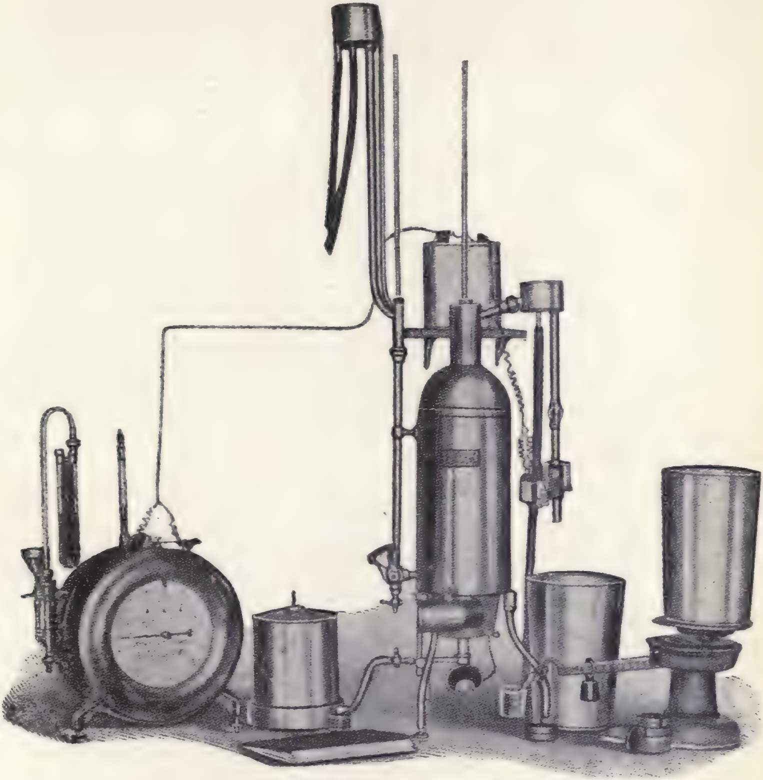
**(7) Fuming Sulphuric Acid.**

Ordinary concentrated sulphuric acid is mixed with an equal weight of sulphuric anhydride. One cc. of this reagent absorbs 8 cc. of olefins or illuminants.

**(8) Palladium Chloride.**

Five grams of palladium wire are dissolved in a solution of 30 cc. of hydrochloric acid and 2 cc. of nitric acid.

The solution is evaporated to dryness on a water bath, 5 cc. of hydrochloric acid are added and 25 cc. of water and complete solution is made. The solution is diluted to 750 cc. It contains one per cent palladous chloride and 1 cc. absorbs 2/3 of 1 cc. of hydrogen.



Sargent Gas Calorimeter.

**35A. DETERMINATION OF THE HEATING VALUE OF GAS.**

The most common instruments used for determining heating value of gas are the Junker, the Parr and the Sargent calorimeters. The Sargent is a very convenient instrument and is described as follows:

The figure on page 363 shows a section of the calorimeter body in which the inlet body has a constant heat at the wier A, the temperature of which is taken at B, passes down the tube C and enters the

calorimeter at D. The quantity of water admitted is regulated by the graduated cock between C and D. When water reached D it is spread by the baffle plates E and F and flows upward around the tubes G through which the products of combustion pass downward. The partially heated water on leaving the tubes spreads out over the dome sheet H, where it is heated by the hottest gases and then passes to the wier K through the baffle plate I around the thermometer J, where the outlet temperature is taken. From the wier K it overflows to the waste until test begins, after which it goes through the cock below the wier to the automatic tipping bucket, which is a two-compartment funnel mounted on pivots held in extreme position by the latch so that the water to be weighed runs from one compartment to the receiving pail, while the meter needle is making one revolution or a tenth of a foot of gas is burned. As soon as the circuit is closed by the meter needle the current passing through the solenoid adjacent to the tipping bucket raises the armature, permitting the weight of water flowing through one compartment of the tipping bucket to swing it to a new position, thereby discharging water for the next tenth of a foot of gas burned into the empty pail. While this pail is filling the filled pail is weighed and the B. T. U. may be determined and recorded while another tenth of a foot of gas is burned and continuous and correct results may be obtained and recorded as long as desired. The general set-up of the calorimeter is shown on page 361. The following method of calculating the B. T. U. is used:

$t_1$ = temperature of incoming water.
$t_2$ = temperature of outgoing water.
w = pounds of water passed through.
c = pounds of water condensed (average for each 0.1 cu. ft.).
From which B. T. U. per cubic foot =
$10\ (w + c + 0.02)\ (t_2 - t_1) - 9704\ c.$
Example:
$t_1 = 63.0°F.$
$t_2 = 111.0°F.$
w = 1.7531 lbs.
c = 0.0091 lb.
$10\ (1.7531 + 0.0091 + 0.02)\ (111.0 - 63.0) - (9704)\ (.0091) = 855.3 - 88.3 = 767$ B. T. U. per cubic foot.

## 35-B. APPROXIMATE HEATING VALUE OF NATURAL GAS BY CALCULATION.

The natural gas is burned with an excess of oxygen in a regular combustion pipet J as shown in the apparatus on page 358.

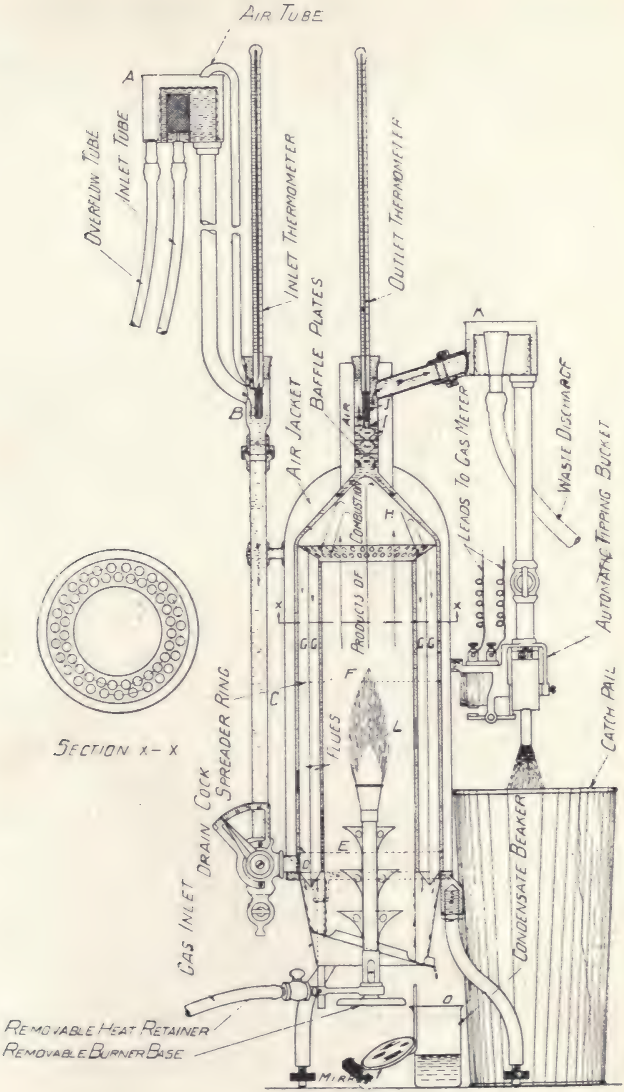
B. T. U. per cu. ft. is equal to $504 \dfrac{V}{V_n}$ where $V_o$ = volume of oxygen consumed in burning $V_n$ volumes of natural gas.

## 35-C. B. T. U. OF GAS BY CALCULATION FROM ANALYSIS.

The heating value of natural gas or any other gas may be calculated as follows:

| | | |
|---|---|---|
| Percentage of illuminates | x 20.00 | = |
| Percentage of CO | x 3.41 | = |
| Percentage of $CH_4$ | x 10.65 | = |
| Percentage of $H_2$ | x 3.45 | = |

The sum of these is the B. T. U. per cubic ft. =




SECTIONAL ELEVATION
SARGENT AUTOMATIC GAS CALORIMETER

**Factors for reduction volume of gas to 60°F. and 30 in. of mercury pressure and saturation with moisture.**

| TEMPERATURE °F. | BAROMETER 28.6 | 28.7 | 28.8 | 28.9 | 29.0 | 29.1 | 29.2 | 29.3 | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 30.0 | 30.1 | 30.2 | 30.3 | 30.4 | 30.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 0.969 | 0.973 | 0.976 | 0.980 | 0.983 | 0.986 | 0.990 | 0.993 | 0.997 | 1.000 | 1.004 | 1.007 | 1.011 | 1.014 | 1.018 | 1.021 | 1.025 | 1.028 | 1.031 | 1.035 |
| 52 | 0.971 | 0.975 | 0.978 | 0.982 | 0.985 | 0.989 | 0.992 | 0.996 | 0.999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 | 1.024 | 1.027 | 1.031 | 1.034 | 1.038 |
| 51 | 0.974 | 0.977 | 0.981 | 0.984 | 0.988 | 0.991 | 0.995 | 0.998 | 1.002 | 1.005 | 1.009 | 1.012 | 1.016 | 1.019 | 1.023 | 1.026 | 1.030 | 1.033 | 1.037 | 1.040 |
| 50 | 0.976 | 0.980 | 0.983 | 0.987 | 0.990 | 0.994 | 0.997 | 1.001 | 1.004 | 1.008 | 1.011 | 1.015 | 1.018 | 1.022 | 1.025 | 1.029 | 1.032 | 1.036 | 1.039 | 1.043 |
| 49 | 0.979 | 0.982 | 0.986 | 0.989 | 0.993 | 0.996 | 1.000 | 1.003 | 1.007 | 1.010 | 1.014 | 1.017 | 1.021 | 1.024 | 1.028 | 1.031 | 1.035 | 1.038 | 1.042 | 1.045 |
| 48 | 0.981 | 0.985 | 0.988 | 0.992 | 0.995 | 0.998 | 1.002 | 1.006 | 1.009 | 1.013 | 1.016 | 1.020 | 1.023 | 1.027 | 1.030 | 1.034 | 1.037 | 1.041 | 1.044 | 1.048 |
| 47 | 0.984 | 0.987 | 0.991 | 0.994 | 0.998 | 1.001 | 1.005 | 1.008 | 1.012 | 1.015 | 1.019 | 1.022 | 1.026 | 1.029 | 1.033 | 1.036 | 1.040 | 1.043 | 1.047 | 1.050 |
| 46 | 0.986 | 0.990 | 0.993 | 0.997 | 1.000 | 1.004 | 1.007 | 1.011 | 1.014 | 1.018 | 1.021 | 1.025 | 1.028 | 1.032 | 1.035 | 1.039 | 1.042 | 1.046 | 1.049 | 1.053 |
| 45 | 0.989 | 0.992 | 0.996 | 0.999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 | 1.024 | 1.027 | 1.031 | 1.034 | 1.038 | 1.041 | 1.045 | 1.048 | 1.052 | 1.056 |
| 44 | 0.991 | 0.994 | 0.998 | 1.001 | 1.005 | 1.008 | 1.012 | 1.015 | 1.019 | 1.022 | 1.026 | 1.029 | 1.033 | 1.036 | 1.040 | 1.043 | 1.047 | 1.050 | 1.054 | 1.058 |
| 43 | 0.993 | 0.997 | 1.001 | 1.004 | 1.008 | 1.011 | 1.015 | 1.018 | 1.022 | 1.025 | 1.029 | 1.032 | 1.036 | 1.039 | 1.043 | 1.046 | 1.050 | 1.053 | 1.057 | 1.060 |
| 42 | 0.995 | 0.999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 | 1.024 | 1.027 | 1.031 | 1.034 | 1.038 | 1.041 | 1.045 | 1.048 | 1.052 | 1.055 | 1.059 | 1.063 |
| 41 | 0.998 | 1.001 | 1.005 | 1.009 | 1.012 | 1.016 | 1.019 | 1.023 | 1.026 | 1.030 | 1.034 | 1.037 | 1.041 | 1.044 | 1.048 | 1.051 | 1.055 | 1.058 | 1.062 | 1.065 |
| 40 | 1.000 | 1.004 | 1.007 | 1.011 | 1.014 | 1.018 | 1.021 | 1.025 | 1.028 | 1.032 | 1.036 | 1.039 | 1.043 | 1.046 | 1.050 | 1.053 | 1.057 | 1.060 | 1.064 | 1.068 |
| 39 | 1.002 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 | 1.024 | 1.028 | 1.031 | 1.035 | 1.038 | 1.042 | 1.045 | 1.049 | 1.052 | 1.056 | 1.059 | 1.063 | 1.066 | 1.070 |
| 38 | 1.005 | 1.009 | 1.012 | 1.016 | 1.020 | 1.023 | 1.027 | 1.030 | 1.034 | 1.037 | 1.041 | 1.044 | 1.048 | 1.051 | 1.055 | 1.058 | 1.062 | 1.065 | 1.069 | 1.073 |
| 37 | 1.007 | 1.011 | 1.015 | 1.018 | 1.022 | 1.025 | 1.029 | 1.032 | 1.036 | 1.039 | 1.043 | 1.046 | 1.050 | 1.053 | 1.057 | 1.060 | 1.064 | 1.068 | 1.072 | 1.076 |
| 36 | 1.009 | 1.013 | 1.017 | 1.020 | 1.024 | 1.027 | 1.031 | 1.035 | 1.038 | 1.042 | 1.045 | 1.049 | 1.052 | 1.056 | 1.060 | 1.063 | 1.067 | 1.071 | 1.074 | 1.078 |
| 35 | 1.012 | 1.015 | 1.019 | 1.022 | 1.026 | 1.030 | 1.033 | 1.037 | 1.041 | 1.044 | 1.048 | 1.051 | 1.055 | 1.058 | 1.062 | 1.065 | 1.069 | 1.073 | 1.077 | 1.081 |
| 34 | 1.014 | 1.018 | 1.022 | 1.025 | 1.029 | 1.032 | 1.036 | 1.040 | 1.043 | 1.047 | 1.050 | 1.054 | 1.057 | 1.061 | 1.064 | 1.068 | 1.072 | 1.075 | 1.079 | 1.083 |
| 33 | 1.016 | 1.020 | 1.024 | 1.027 | 1.031 | 1.034 | 1.038 | 1.042 | 1.046 | 1.049 | 1.053 | 1.056 | 1.060 | 1.063 | 1.067 | 1.070 | 1.074 | 1.078 | 1.082 | 1.086 |
| 32 | 1.019 | 1.023 | 1.027 | 1.030 | 1.034 | 1.037 | 1.041 | 1.044 | 1.048 | 1.051 | 1.055 | 1.058 | 1.062 | 1.066 | 1.069 | 1.073 | 1.077 | 1.081 | 1.085 | 1.089 |
| 31 | 1.021 | 1.025 | 1.029 | 1.032 | 1.036 | 1.039 | 1.043 | 1.047 | 1.050 | 1.054 | 1.057 | 1.061 | 1.064 | 1.068 | 1.072 | 1.075 | 1.079 | 1.083 | 1.087 | 1.091 |
| 30 | 1.023 | 1.027 | 1.031 | 1.034 | 1.038 | 1.042 | 1.045 | 1.049 | 1.052 | 1.056 | 1.060 | 1.063 | 1.067 | 1.071 | 1.074 | 1.078 | 1.082 | 1.086 | 1.090 | 1.094 |

| | BAROMETER | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEMPERATURE °F. | 28.6 | 28.7 | 28.8 | 28.9 | 29.0 | 29.1 | 29.2 | 29.3 | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 30.0 | 30.1 | 30.2 | 30.3 | 30.4 | 30.5 |
| 107 | 0.816 | 0.820 | 0.823 | 0.826 | 0.829 | 0.832 | 0.835 | 0.838 | 0.841 | 0.844 | 0.847 | 0.851 | 0.854 | 0.857 | 0.860 | 0.864 | 0.86 | 0.870 | 0.874 | 0.877 |
| 106 | 0.820 | 0.823 | 0.826 | 0.829 | 0.832 | 0.835 | 0.838 | 0.841 | 0.844 | 0.847 | 0.851 | 0.854 | 0.857 | 0.860 | 0.863 | 0.867 | 0.870 | 0.874 | 0.878 | 0.881 |
| 105 | 0.823 | 0.827 | 0.830 | 0.833 | 0.836 | 0.839 | 0.842 | 0.845 | 0.848 | 0.851 | 0.855 | 0.858 | 0.861 | 0.864 | 0.867 | 0.871 | 0.874 | 0.878 | 0.881 | 0.884 |
| 104 | 0.827 | 0.830 | 0.833 | 0.836 | 0.839 | 0.842 | 0.845 | 0.848 | 0.851 | 0.854 | 0.858 | 0.861 | 0.864 | 0.867 | 0.871 | 0.874 | 0.878 | 0.881 | 0.884 | 0.887 |
| 103 | 0.830 | 0.834 | 0.837 | 0.840 | 0.843 | 0.847 | 0.849 | 0.852 | 0.855 | 0.858 | 0.862 | 0.865 | 0.868 | 0.871 | 0.874 | 0.878 | 0.881 | 0.885 | 0.888 | 0.891 |
| 102 | 0.834 | 0.837 | 0.840 | 0.843 | 0.847 | 0.850 | 0.853 | 0.856 | 0.859 | 0.862 | 0.865 | 0.868 | 0.871 | 0.874 | 0.878 | 0.881 | 0.885 | 0.888 | 0.891 | 0.894 |
| 101 | 0.837 | 0.840 | 0.843 | 0.846 | 0.850 | 0.853 | 0.856 | 0.859 | 0.862 | 0.865 | 0.868 | 0.872 | 0.875 | 0.878 | 0.882 | 0.885 | 0.888 | 0.891 | 0.895 | 0.898 |
| 100 | 0.840 | 0.843 | 0.846 | 0.849 | 0.853 | 0.856 | 0.859 | 0.862 | 0.865 | 0.868 | 0.872 | 0.875 | 0.878 | 0.881 | 0.885 | 0.888 | 0.891 | 0.895 | 0.898 | 0.901 |
| 99 | 0.844 | 0.847 | 0.850 | 0.853 | 0.857 | 0.860 | 0.863 | 0.866 | 0.869 | 0.872 | 0.876 | 0.879 | 0.882 | 0.885 | 0.889 | 0.892 | 0.895 | 0.898 | 0.902 | 0.905 |
| 98 | 0.847 | 0.850 | 0.853 | 0.856 | 0.860 | 0.863 | 0.866 | 0.869 | 0.872 | 0.875 | 0.879 | 0.882 | 0.885 | 0.888 | 0.892 | 0.895 | 0.898 | 0.902 | 0.905 | 0.908 |
| 97 | 0.850 | 0.853 | 0.856 | 0.859 | 0.863 | 0.866 | 0.870 | 0.873 | 0.876 | 0.879 | 0.882 | 0.885 | 0.888 | 0.891 | 0.894 | 0.898 | 0.901 | 0.905 | 0.908 | 0.911 |
| 96 | 0.854 | 0.857 | 0.860 | 0.863 | 0.867 | 0.870 | 0.873 | 0.876 | 0.879 | 0.882 | 0.886 | 0.889 | 0.892 | 0.895 | 0.898 | 0.901 | 0.904 | 0.908 | 0.911 | 0.914 |
| 95 | 0.857 | 0.860 | 0.863 | 0.866 | 0.870 | 0.873 | 0.876 | 0.879 | 0.882 | 0.885 | 0.889 | 0.892 | 0.895 | 0.898 | 0.901 | 0.904 | 0.908 | 0.911 | 0.914 | 0.918 |
| 94 | 0.860 | 0.863 | 0.866 | 0.869 | 0.873 | 0.876 | 0.879 | 0.882 | 0.885 | 0.888 | 0.892 | 0.895 | 0.898 | 0.901 | 0.904 | 0.907 | 0.911 | 0.914 | 0.918 | 0.921 |
| 93 | 0.863 | 0.866 | 0.869 | 0.872 | 0.876 | 0.879 | 0.883 | 0.886 | 0.889 | 0.891 | 0.895 | 0.898 | 0.901 | 0.904 | 0.907 | 0.910 | 0.914 | 0.918 | 0.921 | 0.924 |
| 92 | 0.866 | 0.869 | 0.872 | 0.875 | 0.879 | 0.882 | 0.885 | 0.889 | 0.892 | 0.894 | 0.898 | 0.902 | 0.904 | 0.907 | 0.910 | 0.914 | 0.917 | 0.921 | 0.924 | 0.928 |
| 91 | 0.869 | 0.872 | 0.875 | 0.879 | 0.882 | 0.885 | 0.889 | 0.892 | 0.895 | 0.898 | 0.902 | 0.905 | 0.908 | 0.911 | 0.914 | 0.917 | 0.921 | 0.924 | 0.928 | 0.931 |
| 90 | 0.872 | 0.875 | 0.878 | 0.881 | 0.885 | 0.888 | 0.892 | 0.895 | 0.898 | 0.901 | 0.905 | 0.908 | 0.911 | 0.914 | 0.917 | 0.920 | 0.924 | 0.927 | 0.931 | 0.934 |
| 89 | 0.875 | 0.878 | 0.882 | 0.885 | 0.889 | 0.892 | 0.895 | 0.898 | 0.901 | 0.904 | 0.907 | 0.910 | 0.914 | 0.917 | 0.920 | 0.923 | 0.927 | 0.931 | 0.934 | 0.937 |
| 88 | 0.878 | 0.881 | 0.885 | 0.888 | 0.892 | 0.895 | 0.898 | 0.901 | 0.904 | 0.907 | 0.910 | 0.913 | 0.917 | 0.920 | 0.923 | 0.926 | 0.930 | 0.934 | 0.937 | 0.940 |
| 87 | 0.881 | 0.884 | 0.888 | 0.891 | 0.895 | 0.898 | 0.901 | 0.904 | 0.907 | 0.910 | 0.913 | 0.916 | 0.920 | 0.923 | 0.926 | 0.929 | 0.933 | 0.937 | 0.940 | 0.943 |
| 86 | 0.884 | 0.887 | 0.890 | 0.894 | 0.898 | 0.901 | 0.904 | 0.907 | 0.910 | 0.913 | 0.916 | 0.919 | 0.923 | 0.926 | 0.929 | 0.932 | 0.936 | 0.940 | 0.943 | 0.946 |
| 85 | 0.887 | 0.890 | 0.893 | 0.896 | 0.900 | 0.903 | 0.906 | 0.909 | 0.913 | 0.916 | 0.919 | 0.922 | 0.926 | 0.929 | 0.932 | 0.936 | 0.939 | 0.943 | 0.946 | 0.949 |
| 84 | 0.889 | 0.893 | 0.896 | 0.899 | 0.903 | 0.906 | 0.909 | 0.912 | 0.915 | 0.919 | 0.922 | 0.925 | 0.928 | 0.932 | 0.935 | 0.939 | 0.942 | 0.946 | 0.949 | 0.952 |
| 83 | 0.892 | 0.895 | 0.899 | 0.902 | 0.906 | 0.909 | 0.912 | 0.915 | 0.918 | 0.921 | 0.924 | 0.928 | 0.937 | 0.935 | 0.938 | 0.942 | 0.945 | 0.949 | 0.952 | 0.955 |
| 82 | 0.895 | 0.898 | 0.901 | 0.905 | 0.908 | 0.911 | 0.914 | 0.918 | 0.921 | 0.924 | 0.927 | 0.931 | 0.934 | 0.937 | 0.941 | 0.945 | 0.948 | 0.951 | 0.954 | 0.958 |
| 81 | 0.898 | 0.901 | 0.905 | 0.908 | 0.911 | 0.914 | 0.917 | 0.921 | 0.924 | 0.927 | 0.930 | 0.934 | 0.937 | 0.940 | 0.944 | 0.948 | 0.951 | 0.954 | 0.957 | 0.960 |

| TEMPERATURE °F. | BAROMETER | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 28.6 | 28.7 | 28.8 | 28.9 | 29.0 | 29.1 | 29.2 | 29.3 | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 30.0 | 30.1 | 30.2 | 30.3 | 30.4 | 30.5 |
| 80 | 0.901 | 0.904 | 0.907 | 0.910 | 0.914 | 0.917 | 0.920 | 0.923 | 0.927 | 0.930 | 0.933 | 0.937 | 0.940 | 0.943 | 0.946 | 0.950 | 0.954 | 0.957 | 0.960 | 0.963 |
| 79 | 0.904 | 0.907 | 0.910 | 0.914 | 0.917 | 0.920 | 0.923 | 0.926 | 0.930 | 0.933 | 0.936 | 0.939 | 0.943 | 0.946 | 0.949 | 0.953 | 0.956 | 0.960 | 0.963 | 0.967 |
| 78 | 0.906 | 0.909 | 0.913 | 0.916 | 0.919 | 0.923 | 0.926 | 0.929 | 0.932 | 0.936 | 0.939 | 0.942 | 0.946 | 0.949 | 0.952 | 0.956 | 0.959 | 0.962 | 0.966 | 0.969 |
| 77 | 0.909 | 0.912 | 0.915 | 0.919 | 0.922 | 0.925 | 0.928 | 0.931 | 0.935 | 0.938 | 0.942 | 0.945 | 0.948 | 0.951 | 0.955 | 0.958 | 0.962 | 0.965 | 0.968 | 0.972 |
| 76 | 0.911 | 0.915 | 0.918 | 0.921 | 0.925 | 0.928 | 0.931 | 0.935 | 0.938 | 0.941 | 0.944 | 0.948 | 0.951 | 0.954 | 0.958 | 0.961 | 0.964 | 0.968 | 0.971 | 0.975 |
| 75 | 0.914 | 0.917 | 0.921 | 0.924 | 0.928 | 0.931 | 0.934 | 0.937 | 0.940 | 0.943 | 0.947 | 0.950 | 0.954 | 0.957 | 0.960 | 0.963 | 0.967 | 0.971 | 0.974 | 0.978 |
| 74 | 0.917 | 0.920 | 0.924 | 0.927 | 0.930 | 0.933 | 0.937 | 0.940 | 0.943 | 0.947 | 0.950 | 0.953 | 0.957 | 0.960 | 0.963 | 0.966 | 0.970 | 0.973 | 0.977 | 0.980 |
| 73 | 0.920 | 0.923 | 0.926 | 0.930 | 0.933 | 0.936 | 0.940 | 0.943 | 0.946 | 0.949 | 0.953 | 0.956 | 0.960 | 0.963 | 0.966 | 0.969 | 0.972 | 0.976 | 0.980 | 0.983 |
| 72 | 0.922 | 0.925 | 0.929 | 0.932 | 0.935 | 0.939 | 0.942 | 0.945 | 0.949 | 0.952 | 0.955 | 0.959 | 0.962 | 0.965 | 0.968 | 0.972 | 0.975 | 0.979 | 0.982 | 0.986 |
| 71 | 0.925 | 0.928 | 0.931 | 0.935 | 0.938 | 0.941 | 0.945 | 0.948 | 0.951 | 0.954 | 0.958 | 0.961 | 0.965 | 0.968 | 0.971 | 0.975 | 0.978 | 0.981 | 0.985 | 0.989 |
| 70 | 0.927 | 0.931 | 0.934 | 0.937 | 0.941 | 0.944 | 0.947 | 0.950 | 0.954 | 0.957 | 0.960 | 0.964 | 0.967 | 0.970 | 0.974 | 0.977 | 0.980 | 0.984 | 0.988 | 0.991 |
| 69 | 0.930 | 0.933 | 0.937 | 0.940 | 0.944 | 0.947 | 0.950 | 0.953 | 0.957 | 0.960 | 0.963 | 0.967 | 0.970 | 0.973 | 0.977 | 0.980 | 0.983 | 0.987 | 0.990 | 0.994 |
| 68 | 0.932 | 0.936 | 0.939 | 0.942 | 0.946 | 0.949 | 0.952 | 0.956 | 0.959 | 0.962 | 0.966 | 0.969 | 0.972 | 0.976 | 0.979 | 0.983 | 0.986 | 0.989 | 0.993 | 0.997 |
| 67 | 0.935 | 0.938 | 0.942 | 0.945 | 0.949 | 0.952 | 0.955 | 0.959 | 0.962 | 0.965 | 0.968 | 0.972 | 0.975 | 0.979 | 0.982 | 0.985 | 0.989 | 0.992 | 0.996 | 1.000 |
| 66 | 0.938 | 0.941 | 0.944 | 0.948 | 0.951 | 0.954 | 0.958 | 0.961 | 0.964 | 0.968 | 0.971 | 0.974 | 0.978 | 0.981 | 0.985 | 0.988 | 0.992 | 0.995 | 0.998 | 1.002 |
| 65 | 0.941 | 0.944 | 0.947 | 0.950 | 0.954 | 0.957 | 0.960 | 0.963 | 0.967 | 0.970 | 0.973 | 0.977 | 0.980 | 0.984 | 0.987 | 0.991 | 0.994 | 0.997 | 1.001 | 1.005 |
| 64 | 0.943 | 0.946 | 0.949 | 0.953 | 0.956 | 0.959 | 0.963 | 0.966 | 0.969 | 0.973 | 0.976 | 0.980 | 0.983 | 0.986 | 0.990 | 0.904 | 0.997 | 1.000 | 1.004 | 1.008 |
| 63 | 0.945 | 0.949 | 0.952 | 0.955 | 0.959 | 0.962 | 0.965 | 0.969 | 0.972 | 0.975 | 0.979 | 0.982 | 0.985 | 0.989 | 0.993 | 0.996 | 1.000 | 1.003 | 1.006 | 1.010 |
| 62 | 0.947 | 0.951 | 0.954 | 0.958 | 0.961 | 0.964 | 0.968 | 0.971 | 0.975 | 0.978 | 0.981 | 0.985 | 0.988 | 0.991 | 0.995 | 0.999 | 1.002 | 1.005 | 1.009 | 1.013 |
| 61 | 0.950 | 0.954 | 0.957 | 0.961 | 0.964 | 0.967 | 0.971 | 0.974 | 0.977 | 0.981 | 0.984 | 0.987 | 0.991 | 0.994 | 0.998 | 1.001 | 1.005 | 1.008 | 1.011 | 1.015 |
| 60 | 0.952 | 0.956 | 0.959 | 0.963 | 0.966 | 0.969 | 0.973 | 0.976 | 0.980 | 0.983 | 0.986 | 0.990 | 0.993 | 0.997 | 1.000 | 1.004 | 1.007 | 1.010 | 1.014 | 1.017 |
| 59 | 0.955 | 0.959 | 0.962 | 0.966 | 0.969 | 0.972 | 0.976 | 0.979 | 0.983 | 0.986 | 0.989 | 0.992 | 0.995 | 0.999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.016 | 1.020 |
| 58 | 0.957 | 0.961 | 0.964 | 0.968 | 0.971 | 0.975 | 0.978 | 0.981 | 0.985 | 0.988 | 0.992 | 0.995 | 0.998 | 1.002 | 1.005 | 1.009 | 1.012 | 1.016 | 1.019 | 1.023 |
| 57 | 0.960 | 0.963 | 0.967 | 0.970 | 0.974 | 0.977 | 0.980 | 0.984 | 0.988 | 0.991 | 0.994 | 0.997 | 1.000 | 1.004 | 1.007 | 1.011 | 1.014 | 1.018 | 1.021 | 1.025 |
| 56 | 0.962 | 0.966 | 0.969 | 0.973 | 0.976 | 0.979 | 0.982 | 0.986 | 0.990 | 0.993 | 0.996 | 1.000 | 1.003 | 1.007 | 1.010 | 1.014 | 1.017 | 1.021 | 1.024 | 1.028 |
| 55 | 0.965 | 0.968 | 0.972 | 0.975 | 0.979 | 0.982 | 0.985 | 0.989 | 0.993 | 0.996 | 0.999 | 1.002 | 1.005 | 1.009 | 1.013 | 1.016 | 1.020 | 1.023 | 1.027 | 1.030 |
| 54 | 0.967 | 0.970 | 0.974 | 0.977 | 0.981 | 0.984 | 0.988 | 0.991 | 0.995 | 0.998 | 1.001 | 1.005 | 1.008 | 1.012 | 1.015 | 1.019 | 1.022 | 1.026 | 1.029 | 1.033 |

# Comparison of Temperatures by the Fahrenheit and Centigrade Scales

| Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. |
|---|---|---|---|---|---|---|---|
| —273° | —459.4 | | | | | | |
| Absolute Zero | | | | | | | |
| —200° | —328.0 | — 5.6 | +22.0 | 15.6 | 60.0 | 36.1 | 97.0 |
| Temperature of | | — 5.0 | +23.0 | 16.0 | 60.8 | 36.7 | 98.0 |
| Liquid Air | | — 4.4 | +24.0 | 16.1 | 61.0 | 37.0 | 98.6 |
| —130° | —202.0 | — 4.0 | +24.8 | 16.7 | 62.0 | 37.2 | 99.0 |
| Pure Grain Alcohol | | — 3.9 | +25.0 | 17.0 | 62.6 | 37.8 | 100.0 |
| Freezes | | — 3.3 | +26.0 | 17.2 | 63 0 | 38.0 | 100.4 |
| —70° | —94.0 | — 3.0 | +26.6 | 17.8 | 64.0 | 38.3 | 101.0 |
| Ammonia Freezes | | — 2.8 | +27.0 | 18.0 | 64.4 | 38.9 | 102.0 |
| —(75°C) | | — 2.2 | +28.0 | 18.3 | 65.0 | 39.0 | 102.2 |
| —40° | —40. | — 2.0 | +28.4 | 18.9 | 66.0 | 39.4 | 103.0 |
| Mercury Freezes | | — 1.7 | +29.0 | 19.0 | 66.2 | 40.0 | 104.0 |
| (—39.5C) | | — 1.1 | +30.0 | 19.4 | 67.0 | 40.6 | 105.0 |
| —30° | —22 | — 1.0 | +30.2 | 20.0 | 68.0 | 41.0 | 105.8 |
| Ammonia Liquefies | | — 0.6 | +31.0 | 20.6 | 69.0 | 41.1 | 106.0 |
| at —33.7°C | | 0. | +32.0 | 21.0 | 69.8 | 41.7 | 107.0 |
| —28 | —18.4 | + 0.6 | +33.0 | 21.1 | 70.0 | 42.0 | 107.6 |
| —26 | —14.8 | 1.0 | 33.8 | 21.7 | 71.0 | 42.2 | 108.0 |
| —24 | —11.2 | 1.1 | 34.0 | 22.0 | 71.6 | 42.8 | 109.0 |
| —22 | — 7.6 | 1.7 | 35.0 | 22.2 | 72.0 | 43.0 | 109.4 |
| —20 | — 4.0 | 2.0 | 35.6 | 22.8 | 73.0 | 43.3 | 110.0 |
| —19 | — 2.2 | 2.2 | 36.0 | 23.0 | 73.4 | 43.9 | 111.0 |
| —18 | — 0.4 | 2.8 | 37.0 | 23.3 | 74.0 | 44.0 | 111.2 |
| —17.8 | — 0.0 | 3.0 | 37.4 | 23.9 | 75.0 | 44.4 | 112.0 |
| —17.2 | + 1.0 | 3.3 | 38.0 | 24.0 | 75.2 | 45.0 | 113.0 |
| —17.0 | + 1.4 | 3.9 | 39.0 | 24.4 | 76.0 | 45.6 | 114.0 |
| —16.7 | + 2.0 | 4.0 | 39.2 | 25.0 | 77.0 | 46.0 | 114.8 |
| —16.1 | + 3.0 | 4.4 | 40.0 | 25.6 | 78.0 | 46.1 | 115.0 |
| —16.0 | + 3.2 | 5.0 | 41.0 | 26.0 | 78.8 | 46.7 | 116.0 |
| —15.6 | + 4.0 | 5.6 | 42.0 | 26.1 | 79.0 | 47.0 | 116.6 |
| —15.0 | + 5.0 | 6.0 | 42.8 | 26.7 | 80.0 | 47.2 | 117.0 |
| —14.4 | + 6.0 | 6.1 | 43.0 | 27.0 | 80.6 | 47.8 | 118.0 |
| —14.0 | + 6.8 | 6.7 | 44.0 | 27.2 | 81.0 | 48.0 | 118.4 |
| —13.9 | + 7.0 | 7.0 | 44.6 | 27.8 | 82.0 | 48.3 | 119.0 |
| —13.3 | + 8.0 | 7.2 | 45.0 | 28.0 | 82.4 | 48.9 | 120.0 |
| —13.0 | + 8.6 | 7.8 | 46.0 | 28.3 | 83.0 | 49.0 | 120.2 |
| —12.8 | + 9.0 | 8.0 | 46.4 | 28 9 | 84.0 | 49.4 | 121.0 |
| —12.2 | +10.0 | 8.3 | 47.0 | 29.0 | 84.2 | 50.0 | 122.0 |
| —12.0 | +10.4 | 8.9 | 48.0 | 29.4 | 85.0 | 50.6 | 123.0 |
| —11.7 | +11.0 | 9.0 | 48.2 | 30.0 | 86.0 | 51.0 | 123.8 |
| —11.1 | +12.0 | 9.4 | 49.0 | 30.6 | 87.0 | 51.1 | 124.0 |
| —11.0 | +12.2 | 10.0 | 50.0 | 31.0 | 87.8 | 51.7 | 125.0 |
| —10.6 | +13.0 | 10.6 | 51.0 | 31.1 | 88.0 | 52.0 | 125.6 |
| —10.0 | +14.0 | 11.0 | 51.8 | 31.7 | 89.0 | 52.2 | 126.0 |
| — 9.4 | +15.0 | 11.1 | 52.0 | 32.0 | 89.6 | 52.8 | 127.0 |
| — 9.0 | +15.8 | 11.7 | 53.0 | 32.2 | 90.0 | 53.0 | 127.4 |
| — 8.9 | +16.0 | 12.0 | 53.6 | 32.8 | 91.0 | 53.3 | 128.0 |
| — 8.3 | +17.0 | 12.2 | 54.0 | 33.0 | 91.4 | 53.9 | 129.0 |
| — 8.0 | +17.6 | 12.8 | 55.0 | 33.3 | 92.0 | 54.0 | 129.2 |
| — 7.8 | +18.0 | 13.0 | 55.4 | 33.9 | 93.0 | 54.4 | 130.0 |
| — 7.2 | +19.0 | 13.3 | 56.0 | 34.0 | 93.2 | 55.0 | 131.0 |
| — 7.0 | +19.4 | 13.9 | 57.0 | 34.4 | 94.0 | 55.6 | 132.0 |
| — 6.7 | +20.0 | 14.0 | 57.2 | 35.0 | 95.0 | 56.0 | 132.8 |
| — 6.1 | +21.0 | 14.4 | 58.0 | 35.6 | 96.0 | 56.1 | 133.0 |
| — 6.0 | +21.2 | 15.0 | 59.0 | 36.0 | 96.8 | 56.7 | 134.0 |

# Temperature Conversion Tables

| Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. |
|---|---|---|---|---|---|---|---|
| 57.0 | 134.6 | 77.8 | 172.0 | 98.3 | 209.0 | 119.0 | 246.2 |
| 57.2 | 135.0 | 78.0 | 172.4 | 98.9 | 210.0 | 119.4 | 247.0 |
| 57.8 | 136.0 | 78.3 | 173.0 | 99.0 | 210.2 | 120.0 | 248.0 |
| 58.0 | 136.4 | 78.9 | 174.0 | 99.4 | 211.0 | 120.6 | 249.0 |
| 58.3 | 137.0 | 79.0 | 174.2 | 100.0 | 212.0 | 121.0 | 249.8 |
| 58.9 | 138.0 | 79.4 | 175.0 | 100.6 | 213.0 | 121.1 | 250.0 |
| 59.0 | 138.2 | 80.0 | 176.0 | 101.0 | 213.8 | 121.7 | 251.0 |
| 59.4 | 139.0 | 80.6 | 177.0 | 101.1 | 214.0 | 122.0 | 251.6 |
| 60.0 | 140.0 | 81.0 | 177.8 | 101.7 | 215.0 | 122.2 | 252.0 |
| 60.6 | 141.0 | 81.1 | 178.0 | 102.0 | 215.6 | 122.8 | 253.0 |
| 61.0 | 141.8 | 81.7 | 179.0 | 102.2 | 216.0 | 123.0 | 253.4 |
| 61.1 | 142.0 | 82.0 | 179.6 | 102.8 | 217.0 | 123.3 | 254.0 |
| 61.7 | 143.0 | 82.2 | 180.0 | 103.0 | 217.4 | 123.9 | 255.0 |
| 62.0 | 143.6 | 82.8 | 181.0 | 103.3 | 218.0 | 124.0 | 255.2 |
| 62.2 | 144.0 | 83.0 | 181.4 | 103.9 | 219.0 | 124.4 | 256.0 |
| 62.8 | 145.0 | 83.3 | 182.0 | 104.0 | 219.2 | 125.0 | 257.0 |
| 63.0 | 145.4 | 83.9 | 183.0 | 104.4 | 220.0 | 125.6 | 258.0 |
| 63.0 | 146.0 | 84.0 | 183.2 | 105.0 | 221.0 | 126.0 | 258.8 |
| 63.9 | 147.0 | 84.4 | 184.0 | 105.6 | 222.0 | 126.1 | 259.0 |
| 64.0 | 147.2 | 85.0 | 185.0 | 106.0 | 222.8 | 126.7 | 260.0 |
| 64.4 | 148.0 | 85.6 | 186.0 | 106.1 | 223.0 | 127.0 | 260.6 |
| 65.0 | 149.0 | 86.0 | 186.8 | 106.7 | 224.0 | 127.2 | 261.0 |
| 65.6 | 150.0 | 86.1 | 187.0 | 107.0 | 224.6 | 127.8 | 262.0 |
| 66.0 | 150.8 | 86.7 | 188.0 | 107.2 | 225.0 | 128.0 | 262.4 |
| 66.1 | 151.0 | 87.0 | 188.6 | 107.8 | 226.0 | 128.3 | 263.0 |
| 66.7 | 152.0 | 87.2 | 189.0 | 108.0 | 226.4 | 128.9 | 264.0 |
| 67.0 | 152.6 | 87.8 | 190.0 | 108.3 | 227.0 | 129.0 | 264.2 |
| 67.2 | 153.0 | 88.0 | 190.4 | 108.9 | 228.0 | 129.4 | 265.0 |
| 67.8 | 154.0 | 88.3 | 191.0 | 109.0 | 228.2 | 130.0 | 266.0 |
| 68.0 | 154.4 | 88.9 | 192.0 | 109.4 | 229.0 | 130.6 | 267.0 |
| 68.3 | 155.0 | 89.0 | 192.2 | 110.0 | 230.0 | 131.0 | 267.8 |
| 68.9 | 156.0 | 89.4 | 193.0 | 110.6 | 231.0 | 131.1 | 268.0 |
| 69.0 | 156.2 | 90.0 | 194.0 | 111.0 | 231.8 | 131.7 | 269.0 |
| 69.4 | 157.0 | 90.6 | 195.0 | 111.1 | 232.0 | 132.0 | 269.6 |
| 70.0 | 158.0 | 91.0 | 195.8 | 111.7 | 233.0 | 132.2 | 270.0 |
| 70.6 | 159.0 | 91.1 | 196.0 | 112.0 | 233.6 | 132.8 | 271.0 |
| 71.0 | 159.8 | 91.7 | 197.0 | 112.2 | 234.0 | 133.0 | 271.4 |
| 71.1 | 160.0 | 92.0 | 197.6 | 112.8 | 235.0 | 133.3 | 272.0 |
| 71.7 | 161.0 | 92.2 | 198.0 | 113.0 | 235.4 | 133.0 | 273.0 |
| 72.0 | 161.6 | 92.8 | 199.0 | 113.3 | 236.0 | 134.0 | 273.2 |
| 72.2 | 162.0 | 93.0 | 199.4 | 113.9 | 237.0 | 134.4 | 274.0 |
| 72.8 | 163.0 | 93.3 | 200.0 | 114.0 | 237.2 | 135.0 | 275.0 |
| 73.0 | 163.4 | 93.9 | 201.0 | 114.4 | 238.0 | 135.6 | 276.0 |
| 73.3 | 164.0 | 94.0 | 201.2 | 115.0 | 239.0 | 136.0 | 276.8 |
| 73.9 | 165.0 | 94.4 | 202.0 | 115.6 | 240.0 | 136.1 | 277.0 |
| 74.0 | 165.2 | 95.0 | 203.0 | 116.0 | 240.8 | 136.7 | 278.0 |
| 74.4 | 166.0 | 95.6 | 204.0 | 116.1 | 241.0 | 137.0 | 278.6 |
| 75.0 | 167.0 | 96.0 | 204.8 | 116.7 | 242.0 | 137.2 | 279.0 |
| 75.6 | 168.0 | 96.1 | 205.0 | 117.0 | 242.6 | 137.8 | 280.0 |
| 76.0 | 168.8 | 96.7 | 206.0 | 117.2 | 243.0 | 138.0 | 280.4 |
| 76.1 | 169.0 | 97.0 | 206.6 | 117.8 | 244.0 | 138.3 | 281.0 |
| 76.7 | 170.0 | 97.2 | 207.0 | 118.0 | 244.4 | 138.9 | 282.0 |
| 77.0 | 170.6 | 97.8 | 208.0 | 118.3 | 245.0 | 139.0 | 282.2 |
| 77.2 | 171.6 | 98.0 | 208.4 | 118.9 | 246.0 | 139.4 | 283.0 |

## TEMPERATURE CONVERSION TABLES—Continued.

| Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. | Cent. | Fahr. |
|---|---|---|---|---|---|---|---|
| 140.0 | 284.0 | 215.0 | 419.0 | 590.0 | 1094.0 | 1360.0 | 2480.0 |
| 140.6 | 285.0 | 220.0 | 428.0 | 600.0 | 1112.0 | 1380.0 | 2516.0 |
| 141.0 | 285.8 | 225.0 | 437.0 | 610.0 | 1130.0 | 1400.0 | 2552.0 |
| 141.1 | 286.0 | 230.0 | 446.0 | 620.0 | 1148.0 | 1420.0 | 2588.0 |
| 141.7 | 287.0 | 235.0 | 455.0 | 630.0 | 1166.0 | 1440.0 | 2624.0 |
| 142.0 | 287.6 | 240.0 | 464.0 | 640.0 | 1184.0 | 1460.0 | 2660.0 |
| 142.2 | 288.0 | 245.0 | 473.0 | 650.0 | 1202.0 | 1480.0 | 2696.0 |
| 142.8 | 289.0 | 250.0 | 482.0 | 660.0 | 1220.0 | 1500.0 | 2732.0 |
| 143.0 | 289.4 | 254.0 | 489.2 | 670.0 | 1238.0 | 1520.0 | 2768.0 |
| 143.3 | 290.0 | 255.0 | 491.0 | 680.0 | 1256.0 | 1540.0 | 2804.0 |
| 143.9 | 291.0 | 260.0 | 500.0 | 690.0 | 1274.0 | 1560.0 | 2840.0 |
| 144.0 | 291.2 | 265.0 | 509.0 | 700.0 | 1292.0 | 1580.0 | 2876.0 |
| 144.4 | 292.0 | 270.0 | 518.0 | 710.0 | 1310.0 | 1600.0 | 2912.0 |
| 145.0 | 293.0 | 275.0 | 527.0 | 720.0 | 1328.0 | 1620.0 | 2918.0 |
| 145.6 | 294.0 | 280.0 | 536.0 | 730.0 | 1346.0 | 1640.0 | 2984.0 |
| 146.0 | 294.8 | 283.0 | 541.4 | 740.0 | 1364.0 | 1660.0 | 3020.0 |
| 146.1 | 295.0 | 285.0 | 545.0 | 750.0 | 1382.0 | 1680.0 | 3056.0 |
| 146.7 | 296.0 | 288.0 | 550.4 | 760.0 | 1400.0 | 1700.0 | 3092.0 |
| 147.0 | 296.6 | 290.0 | 554.0 | 770.0 | 1418.0 | 1720.0 | 3128.0 |
| 147.2 | 297.0 | 295.0 | 563.0 | 780.0 | 1436.0 | 1740.0 | 3164.0 |
| 147.8 | 298.0 | 300.0 | 572.0 | 790.0 | 1454.0 | 1760.0 | 3200.0 |
| 148.0 | 298.4 | 305.0 | 581.0 | 800.0 | 1472.0 | 1780.0 | 3236.0 |
| 148.3 | 299.0 | 310.0 | 590.0 | 810.0 | 1490.0 | 1800.0 | 3272.0 |
| 148.9 | 300.0 | 315.0 | 599.0 | 820.0 | 1508.0 | 1825.0 | 3317.0 |
| 149.0 | 300.2 | 320.0 | 608.0 | 830.0 | 1526.0 | 1850.0 | 3362.0 |
| 149.4 | 301.0 | 325.0 | 617.0 | 840.0 | 1544.0 | 1875.0 | 3407.0 |
| 150.0 | 302.0 | 330.0 | 626.0 | 850.0 | 1562.0 | 1900.0 | 3452.0 |
| 152.0 | 305.6 | 335.0 | 635.0 | 860.0 | 1580.0 | 1925.0 | 3497.0 |
| 154.0 | 309.2 | 340.0 | 644.0 | 870.0 | 1598.0 | 1950.0 | 3542.0 |
| 156.0 | 312.8 | 345.0 | 653.0 | 880.0 | 1616.0 | 1975.0 | 3587.0 |
| 158.0 | 316.4 | 350.0 | 662.0 | 890.0 | 1634.0 | 2000.0 | 3632.0 |
| 160.0 | 320.0 | 360.0 | 680.0 | 900.0 | 1652.0 | 2400.0 | 3812.0 |
| 162.0 | 323.6 | 370.0 | 698.0 | 920.0 | 1688.0 | 2500.0 | 4532.0 |
| 164.0 | 327.2 | 380.0 | 716.0 | 940.0 | 1724.0 | 3000.0 | 5432.0 |
| 166.0 | 330.8 | 390.0 | 734.0 | 960.0 | 1760.0 | 3500.0 | 6332.0 |
| 168.0 | 334.4 | 400.0 | 752.0 | 980.0 | 1796.0 | 4000.0 | 7232.0 |
| 170.0 | 338.0 | 410.0 | 770.0 | 1000.0 | 1832.0 | 5000.0 | 9032.0 |
| 172.0 | 341.6 | 420.0 | 788.0 | 1020.0 | 1868.0 | 6000.0 | 10832.0 |
| 174.0 | 345.2 | 430.0 | 806.0 | 1040.0 | 1904.0 | | |
| 176.0 | 348.8 | 440.0 | 824.0 | 1060.0 | 1940.0 | | |
| 178.0 | 352.4 | 450.0 | 842.0 | 1080.0 | 1976.0 | | |
| 180.0 | 356.0 | 460.0 | 860.0 | 1100.0 | 2012.0 | | |
| 182.0 | 359.6 | 470.0 | 878.0 | 1120.0 | 2048.0 | | |
| 184.0 | 363.2 | 480.0 | 896.0 | 1140.0 | 2084.0 | | |
| 186.0 | 366.8 | 490.0 | 914.0 | 1160.0 | 2120.0 | | |
| 188.0 | 370.4 | 500.0 | 932.0 | 1180.0 | 2156.0 | | |
| 190.0 | 374.0 | 510.0 | 950.0 | 1200.0 | 2192.0 | | |
| 192.0 | 377.6 | 520.0 | 968.0 | 1220.0 | 2228.0 | | |
| 194.0 | 381.2 | 530.0 | 986.0 | 1240.0 | 2264.0 | | |
| 196.0 | 384.8 | 540.0 | 1004.0 | 1260.0 | 2300.0 | | |
| 198.0 | 388.4 | 550.0 | 1022.0 | 1280.0 | 2336.0 | | |
| 200.0 | 392.0 | 560.0 | 1040.0 | 1300.0 | 2372.0 | | |
| 205.0 | 401.0 | 570.0 | 1058.0 | 1320.0 | 2408.0 | | |
| 210.0 | 410.0 | 580.0 | 1076.0 | 1340.0 | 2444.0 | | |

TEMPERATURE READING CONVERSION FACTORS.

Temp. Centigrade = 5/9 (F.—32) = 5/4 R.
Temp. Fahrenheit = 9/5 C. + 32 = 9/4 R. + 32.
Temp. Reaumur = 4/5 C. = 4/9 (F.—32).

## BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON.
## (U. S. BUREAU OF STANDARDS.)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1.0000 | .9993 | .9986 | .9979 | .9972 | .9964 | .9957 | .9950 | .9943 | .9936 |
| | 8.325 | 8.322 | 8.317 | 8.311 | 8.305 | 8.299 | 8.293 | 8.287 | 8.281 | 8.275 |
| 11 | .9929 | .9922 | .9915 | .9908 | .9901 | .9894 | .9887 | .9880 | .9873 | .9866 |
| | 8.269 | 8.263 | 8.258 | 8.252 | 8.246 | 8.240 | 8.234 | 8.228 | 8.223 | 8.217 |
| 12 | .9859 | .9852 | .9815 | .9838 | .9831 | .9825 | .9818 | .9811 | .9804 | .9797 |
| | 8.211 | 8.205 | 8.194 | 8.194 | 8.188 | 8.182 | 8.176 | 8.171 | 8.165 | 8.159 |
| 13 | .9790 | .9783 | .9777 | .9770 | .9763 | .9756 | .9749 | .9743 | .9736 | .9729 |
| | 8.153 | 8.148 | 8.142 | 8.137 | 8.131 | 8.125 | 8.119 | 8.114 | 8.108 | 8.102 |
| 14 | .9722 | .9715 | .9709 | .9702 | .9695 | .9688 | .9682 | .9675 | .9669 | .9662 |
| | 8.096 | 8.091 | 8.086 | 8.080 | 8.074 | 8.069 | 8.063 | 8.058 | 8.052 | 8.047 |
| 15 | .9655 | .9649 | .9642 | .9635 | .9629 | .9622 | .9615 | .9609 | .9602 | .9596 |
| | 8.041 | 8.035 | 8.030 | 8.024 | 8.019 | 8.013 | 8.007 | 8.002 | 7.997 | 7.991 |
| 16 | .9589 | .9582 | .9582 | .9569 | .9563 | .9556 | .9550 | .9543 | .9537 | .9530 |
| | 7.986 | 7.980 | 7.975 | 7.969 | 7.964 | 7.959 | 7.653 | 7.948 | 7.942 | 7.937 |
| 17 | .9524 | .9517 | .9511 | .9504 | .9498 | .9492 | .9485 | .9479 | .9472 | .9466 |
| | 7.931 | 7.926 | 7.921 | 7.915 | 7.910 | 7.904 | 7.899 | 7.894 | 7.888 | 7.883 |
| 18 | .9459 | .9453 | .9447 | .944[illegible] | 9434 | .9428 | .9421 | .9415 | .9409 | .9402 |
| | 7.877 | 7.872 | 7.867 | 7.861 | 7.856 | 7.851 | 7.846 | 7.841 | 7.835 | 7.830 |
| 19 | .9396 | .9390 | .9383 | .9377 | .9371 | .9365 | .9358 | .9352 | .9346 | .9340 |
| | 7.825 | 7.820 | 7.814 | 7.809 | 7.804 | 7.799 | 7.793 | 7.788 | 7.783 | 7.778 |
| 20 | .9333 | .9327 | .9321 | .9315 | .9309 | .9302 | .9296 | .9290 | .9284 | .9278 |
| | 7.772 | 7.767 | 7.762 | 7.757 | 7.752 | 7.747 | 7.742 | 7.736 | 7.731 | 7.726 |
| 21 | .9272 | .9265 | .9259 | .9253 | .9247 | .9241 | .9235 | .9229 | .9223 | .9217 |
| | 7.721 | 7.716 | 7.711 | 7.706 | 7.701 | 7.696 | 7.690 | 7.685 | 7.680 | 7.675 |
| 22 | .9211 | .9204 | .9198 | .9192 | .9186 | .9180 | .9174 | .9168 | .9162 | .9156 |
| | 7,670 | 7.665 | 7.660 | 7.655 | 7.650 | 7.645 | 7.640 | 7.635 | 7.630 | 7.625 |
| 23 | .9150 | .9144 | .9138 | .9132 | .9126 | .9121 | .9115 | .9109 | .9103 | .9097 |
| | 7.620 | 7.615 | 7.610 | 7.605 | 7.600 | 7.595 | 7.590 | 7.585 | 7.580 | 7.575 |
| 24 | .9091 | .9085 | .9079 | .9073 | .9067 | .9061 | .9056 | .9050 | .9044 | .9038 |
| | 7.570 | 7.565 | 7.561 | 7.556 | 7.551 | 7.546 | 7.541 | 7.536 | 7.531 | 7.526 |
| 25 | .9032 | .9026 | .9021 | .9015 | .9009 | .9003 | .8997 | .8992 | .8986 | .8980 |
| | 7.522 | 7.517 | 7.512 | 7.507 | 7.502 | 7.497 | 7.493 | 7.488 | 7.483 | 7.478 |
| 26 | .8974 | .8969 | .8963 | .8957 | .8951 | .8946 | .8940 | .8934 | .8929 | .8923 |
| | 7.473 | 7.469 | 7.464 | 7.459 | 7.454 | 7.449 | 7.445 | 7.440 | 7.435 | 7.430 |
| 27 | .8917 | .8912 | .8906 | .8900 | .8895 | .8889 | .8883 | .8878 | .8872 | .8866 |
| | 7.425 | 7.421 | 7.416 | 7.411 | 7.407 | 7.402 | 7.397 | 7.393 | 7.388 | 7.383 |
| 28 | .8861 | .8855 | .8850 | .8844 | .8838 | .8833 | .8827 | .8822 | .8816 | .8811 |
| | 7.378 | 7.374 | 7.369 | 7.365 | 7.360 | 7.355 | 7.351 | 7.346 | 7.341 | 7.337 |
| 29 | .8805 | .8799 | .8794 | .8788 | .8783 | .8777 | .8772 | .8766 | .8761 | .8755 |
| | 7.332 | 7.328 | 7.323 | 7.318 | 7.314 | 7.309 | 7.305 | 7.300 | 7.295 | 7.291 |
| 30 | .8750 | .8745 | .8739 | .8734 | .8728 | .8723 | .8717 | .8712 | .8706 | .8701 |
| | 7.286 | 7.282 | 7.277 | 7.273 | 7.268 | 7.264 | 7.259 | 7.254 | 7.249 | 7.245 |
| 31 | .8696 | .8690 | .8685 | .8679 | .8674 | .8669 | .8663 | .8658 | .8653 | .8647 |
| | 7.241 | 7.236 | 7.232 | 7.227 | 7.223 | 7.218 | 7.214 | 7.210 | 7.205 | 7.201 |
| 32 | .8642 | .8637 | .8631 | .8626 | .8621 | .8615 | .8610 | .8605 | .8600 | .8594 |
| | 7.196 | 7.192 | 7.187 | 7.183 | 7.178 | 7.173 | 7.169 | 7.165 | 7.161 | 7.156 |
| 33 | .8589 | .8584 | .8578 | .8573 | .8568 | .8563 | .8557 | .8552 | .8547 | .8542 |
| | 7.152 | 7.147 | 7.143 | 7.139 | 7.134 | 7.130 | 7.125 | 7.121 | 7.117 | 7.113 |
| 34 | .8537 | .8531 | .8526 | .8521 | .8516 | .8511 | .8505 | .8500 | .8496 | .8490 |
| | 7.108 | 7.104 | 7.100 | 7.095 | 7.091 | 7.087 | 7.082 | 7.078 | 7.074 | 7.069 |
| 35 | .8485 | .8480 | .8475 | .8469 | .8464 | .8459 | .8454 | .8449 | .8444 | .8439 |
| | 7.065 | 7.061 | 7.057 | 7.052 | 7.048 | 7.044 | 7.039 | 7.035 | 7.031 | 7.027 |
| 36 | .8434 | .8429 | .8424 | .8419 | .8413 | .8408 | .8403 | .8398 | .8393 | .8388 |
| | 7.022 | 7.018 | 7.014 | 7.010 | 7.006 | 7.001 | 6.997 | 6.993 | 6.989 | 6.985 |
| 37 | .8383 | .8378 | .8373 | .8368 | .8363 | .8358 | .8353 | .8348 | .8343 | .8338 |
| | 6.980 | 6.976 | 6.972 | 6.968 | 6.964 | 6.960 | 6.955 | 6.951 | 6.947 | 6.943 |
| 38 | .8333 | .8328 | .8323 | .8318 | .8314 | .8309 | .8304 | .8299 | .8294 | .8289 |
| | 6.939 | 6.935 | 6.930 | 6.926 | 6.922 | 6.918 | 6.914 | 6.910 | 6.906 | 6.902 |

## BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
### U. S. BUREAU OF STANDARDS—Con.

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 39 | .8284 | .8279 | .8274 | .8269 | .8264 | .8260 | .8255 | .8250 | .8245 | .8240 |
| | 6.898 | 6.894 | 6.889 | 6.885 | 6.881 | 6.877 | 6.873 | 6.869 | 6.865 | 6.861 |
| 40 | .8235 | .8230 | .8226 | .8221 | .8216 | .8211 | .8206 | .8202 | .8197 | .8192 |
| | 6.857 | 6.853 | 6.849 | 6.845 | 6.841 | 6.837 | 6.833 | 6.829 | 6.825 | 6.821 |
| 41 | .8187 | .8182 | .8178 | .8173 | .8168 | .8163 | .8159 | .8154 | .8149 | .8144 |
| | 6.817 | 6.813 | 6.809 | 6.805 | 6.801 | 6.797 | 6.793 | 6.789 | 6.785 | 6.781 |
| 42 | .8140 | .8135 | .8130 | .8125 | .8121 | .8116 | .8111 | .8107 | .8102 | .8097 |
| | 6.777 | 6.773 | 6.769 | 6.765 | 6.761 | 6.758 | 6.754 | 6.750 | 6.746 | 6.742 |
| 43 | .8092 | .8088 | .8083 | .8078 | .8074 | .8069 | .8065 | .8060 | .8055 | .8051 |
| | 6.738 | 6.734 | 6.730 | 6.726 | 6.722 | 6.718 | 6.715 | 6.711 | 6.707 | 6.703 |
| 44 | .8046 | .8041 | .8037 | .8032 | .8028 | .8023 | .8018 | .8014 | .8009 | .8005 |
| | 6.699 | 6.695 | 6.691 | 6.688 | 6.684 | 6.680 | 6.676 | 6.672 | 6.668 | 6.665 |
| 45 | .8000 | .7995 | .7991 | .7986 | .7982 | .7977 | .7973 | .7968 | .7964 | .7959 |
| | 6.661 | 6.657 | 6.653 | 6.649 | 6.646 | 6.642 | 6.638 | 6.634 | 6.630 | 6.627 |
| 46 | .7955 | .7950 | .7946 | .7941 | .7937 | .7932 | .7928 | .7923 | .7919 | .7914 |
| | 6.623 | 6.619 | 6.616 | 6.612 | 6.608 | 6.604 | 6.600 | 6.597 | 6.593 | 6.589 |
| 47 | .7910 | .7905 | .7901 | .7896 | .7892 | .7887 | .7883 | .7878 | .7874 | .7870 |
| | 6.586 | 6.582 | 6.578 | 6.574 | 6.571 | 6.567 | 6.563 | 6.560 | 6.556 | 6.552 |
| 48 | .7865 | .7861 | .7856 | .7852 | .7848 | .7843 | .7839 | .7834 | .7830 | .7826 |
| | 6.548 | 6.545 | 6.541 | 6.537 | 6.534 | 6.530 | 6.526 | 6.523 | 6.519 | 6.515 |
| 49 | .7821 | .7817 | .7812 | .7808 | .7804 | .7799 | .7795 | .7791 | .7786 | .7782 |
| | 6.511 | 6.508 | 6.504 | 6.501 | 6.497 | 6.494 | 6.490 | 6.486 | 6.483 | 6.479 |
| 50 | .7778 | .7773 | .7769 | .7765 | .7761 | .7756 | .7752 | .7748 | .7743 | .7739 |
| | 6.476 | 6.472 | 6.468 | 6.465 | 6.461 | 6.458 | 6.454 | 6.450 | 6.447 | 6.443 |
| 51 | .7735 | .7731 | .7726 | .7722 | .7717 | .7713 | .7709 | .7705 | .7701 | .7697 |
| | 6.440 | 6.436 | 6.432 | 6.429 | 6.425 | 6.421 | 6.418 | 6.415 | 6.411 | 6.408 |
| 52 | .7692 | .7688 | .7684 | .7680 | .7675 | .7671 | .7667 | .7663 | .7659 | .7654 |
| | 6.404 | 6.401 | 6.397 | 6.394 | 6.390 | 6.387 | 6.383 | 6.380 | 6.376 | 6.373 |
| 53 | .7650 | .7646 | .7642 | .7638 | .7634 | .7629 | .7625 | .7621 | .7617 | .7613 |
| | 6.369 | 6.366 | 6.362 | 6.359 | 6.355 | 6.351 | 6.348 | 6.345 | 6.341 | 6.338 |
| 54 | .7609 | .7605 | .7600 | .7596 | .7592 | .7588 | .7584 | .7580 | .7576 | .7572 |
| | 6.334 | 6.331 | 6.327 | 6.324 | 6.321 | 6.317 | 6.314 | 6.311 | 6.307 | 6.304 |
| 55 | .7568 | .7563 | .7559 | .7555 | .7551 | .7547 | .7543 | .7539 | .7535 | .7531 |
| | 6.300 | 6.296 | 6.293 | 6.290 | 6.287 | 6.283 | 6.280 | 6.276 | 6.273 | 6.270 |
| 56 | .7527 | .7523 | .7519 | .7515 | .7511 | .7507 | .7503 | .7499 | .7495 | .7491 |
| | 6.266 | 6.263 | 6.250 | 6.256 | 6.253 | 6.249 | 6.246 | 6.243 | 6.240 | 6.236 |
| 57 | .7487 | .7483 | .7479 | .7475 | .7471 | .7467 | .7463 | .7459 | .7455 | .7451 |
| | 6.233 | 6.229 | 6.226 | 6.223 | 6.219 | 6.216 | 6.213 | 6.209 | 6.206 | 6.203 |
| 58 | .7447 | .7443 | .7439 | .7435 | .7431 | .7427 | .7423 | .7419 | .7415 | .7411 |
| | 6.199 | 6.196 | 6.193 | 6.190 | 6.186 | 6.183 | 6.180 | 6.176 | 6.173 | 6.170 |
| 59 | .7407 | .7403 | .7400 | .7396 | .7392 | .7388 | .7384 | .7380 | .7376 | .7372 |
| | 6.166 | 6.163 | 6.160 | 6.157 | 6.154 | 6.150 | 6.147 | 6.144 | 6.141 | 6.137 |
| 60 | .7368 | .7365 | .7361 | .7357 | .7353 | .7349 | .7345 | .7341 | .7338 | .7334 |
| | 6.134 | 6.131 | 6.128 | 6.124 | 6.121 | 6.118 | 6.115 | 6.112 | 6.108 | 6.105 |
| 61 | .7330 | .7326 | .7322 | .7318 | .7315 | .7311 | .7307 | .7303 | .7299 | .7295 |
| | 6.102 | 6.099 | 6.096 | 6.093 | 6.090 | 6.086 | 6.983 | 6.080 | 6.077 | 6.073 |
| 62 | .7292 | .7288 | .7284 | .7280 | .7277 | .7273 | .7269 | .7265 | .7261 | .7258 |
| | 6.070 | 6.067 | 6.064 | 6.060 | 6.057 | 6.054 | 6.051 | 6.948 | 6.045 | 6.042 |
| 63 | .7254 | .7250 | .7246 | .7243 | .7239 | .7235 | .7231 | .7228 | .7224 | .7220 |
| | 6.038 | 6.035 | 6.032 | 6.029 | 6.026 | 6.023 | 6.020 | 6.017 | 6.014 | 6.010 |
| 64 | .7216 | .7213 | .7209 | .7205 | .7202 | .7198 | .7194 | .7191 | .7187 | .7183 |
| | 6.007 | 6.004 | 6.001 | 5.998 | 5.995 | 5.992 | 5.989 | 5.986 | 5.983 | 5.980 |
| 65 | .7179 | .7176 | .7172 | .7168 | .7165 | .7161 | .7157 | .7154 | .7150 | .7147 |
| | 5.976 | 5.973 | 5.970 | 5.967 | 5.964 | 5.961 | 5.958 | 5.955 | 5.952 | 5.949 |
| 66 | .7143 | .7139 | .7136 | .7132 | .7128 | .7125 | .7121 | .7117 | .7114 | .7110 |
| | 5.946 | 5.943 | 5.940 | 5.937 | 5.934 | 5.931 | 5.928 | 5.925 | 5.922 | 5.919 |
| 67 | .7107 | .7103 | .7099 | .7096 | .7092 | .7089 | .7085 | .7081 | .7078 | .7074 |
| | 5.916 | 5.913 | 5.910 | 5.907 | 5.904 | 5.901 | 5.898 | 5.895 | 5.892 | 5.889 |

**BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con**
**U. S. BUREAU OF STANDARDS—Con.**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 68 | .7071 | .7067 | .7064 | .7060 | .7056 | .7053 | .7049 | .7046 | .7042 | .7039 |
| | 5.886 | 5.883 | 5.880 | 5.877 | 5.874 | 5.871 | 5.868 | 5.865 | 5.862 | 5.859 |
| 69 | .7035 | .7032 | .7028 | .7025 | .7021 | .7018 | .7014 | .7011 | .7007 | .7004 |
| | 5.856 | 5.853 | 5.850 | 5.848 | 5.845 | 5.842 | 5.839 | 5.836 | 5.833 | 5.830 |
| 70 | .7000 | .6997 | .6993 | .6990 | .6986 | .6983 | .6979 | .6976 | .6972 | .6669 |
| | 5.827 | 5.824 | 5.821 | 5.818 | 5.815 | 5.812 | 5.810 | 5.807 | 5.804 | 5.801 |
| 71 | .6965 | .6962 | .6958 | .6955 | .6951 | .6948 | .6944 | .6941 | .6938 | .6934 |
| | 5.798 | 5.795 | 5.792 | 5.789 | 5.786 | 5.784 | 5.781 | 5.778 | 5.775 | 5.772 |
| 72 | .6931 | .6927 | .6924 | .6920 | .6917 | .6914 | .6910 | .6907 | .6903 | .6900 |
| | 5.769 | 5.766 | 5.763 | 5.760 | 5.758 | 5.755 | 5.752 | 5.749 | 5.746 | 5.744 |
| 73 | .6897 | .6893 | .6890 | .6886 | .6883 | .6880 | .6876 | .6873 | .6869 | .6866 |
| | 5.741 | 5.738 | 5.735 | 5.732 | 5.729 | 5.727 | 5.724 | 5.721 | 5.718 | 5.715 |
| 74 | .6863 | .6859 | .6856 | .6853 | .6849 | .6846 | .6843 | .6839 | .6836 | .6833 |
| | 5.712 | 5.710 | 5.707 | 5.704 | 5.701 | 5.698 | 5.696 | 5.693 | 5.690 | 5.687 |
| 75 | .6829 | .6826 | .6823 | .6819 | .6816 | .6813 | .6809 | .6806 | .6803 | .6799 |
| | 5.685 | 5.682 | 5.679 | 5.676 | 5.673 | 5.671 | 5.668 | 5.665 | 5.662 | 5.660 |
| 76 | .6796 | .6793 | .6790 | .6786 | .6783 | .6780 | .6776 | .6773 | .6770 | .6767 |
| | 5.657 | 5.654 | 5.652 | 5.649 | 5.646 | 5.643 | 5.640 | 5.638 | 5.635 | 5.632 |
| 77 | .6763 | .6760 | .6757 | .6753 | .6750 | .6747 | .6744 | .6740 | .6737 | .6734 |
| | 5.629 | 5.627 | 5.624 | 5.621 | 5.618 | 5.616 | 5.613 | 5.610 | 5.608 | 5.605 |
| 78 | .6731 | .6728 | .6724 | .6721 | .6718 | .6715 | .6711 | .6708 | .6705 | .6702 |
| | 5.602 | 5.600 | 5.597 | 5.594 | 5.592 | 5.589 | 5.586 | 5.584 | 5.581 | 5.578 |
| 79 | .6699 | .6695 | .6692 | .6689 | .6686 | .6683 | .6679 | .6676 | .6673 | .6670 |
| | 5.576 | 5.573 | 5.570 | 5.568 | 5.565 | 5.562 | 5.560 | 5.557 | 5.554 | 5.552 |
| 80 | .6667 | .6663 | .6660 | .6657 | .6654 | .6651 | .6648 | .6645 | .6641 | .6638 |
| | 5,549 | 5.546 | 5.543 | 5.541 | 5.538 | 5.536 | 5.533 | 5.531 | 5.528 | 5.525 |
| 81 | .6635 | .6632 | .6629 | .6626 | .6623 | .6619 | .6616 | .6613 | .6610 | .6607 |
| | 5.522 | 5.520 | 5.517 | 5.515 | 5.512 | 5.510 | 5.507 | 5.504 | 5.502 | 5.490 |
| 82 | .6604 | .6601 | .6598 | .6594 | .6591 | .6588 | .6585 | .6582 | .6579 | .6576 |
| | 5.497 | 5.494 | 5.491 | 5.489 | 5.486 | 5.484 | 5.481 | 5.478 | 5.476 | 5.473 |
| 83 | .6573 | .6570 | .6567 | .6564 | .6560 | .6557 | .6554 | .6551 | .6548 | .6545 |
| | 5.471 | 5.468 | 5.466 | 5.463 | 5.460 | 5.458 | 5.455 | 5.453 | 5.450 | 5.448 |
| 84 | .6542 | .6539 | .6536 | .6533 | .6530 | .6527 | .6524 | .6521 | .6518 | .6515 |
| | 5.445 | 5.443 | 5.440 | 5.437 | 5.435 | 5.432 | 5.430 | 5.427 | 5.425 | 5.422 |
| 85 | .6512 | .6509 | .6506 | .6503 | .6500 | .6497 | .6494 | .6490 | .6487 | .6484 |
| | 5.420 | 5.417 | 5.415 | 5.412 | 5.410 | 5.407 | 5.405 | 5.402 | 5.400 | 5.397 |
| 86 | .6482 | .6479 | .6476 | .6473 | .6470 | .6467 | .6464 | .6461 | .6558 | .6455 |
| | 5.395 | 5.392 | 5.390 | 5.387 | 5.385 | 5.382 | 5.380 | 5.377 | 5.375 | 5.372 |
| 87 | .6452 | .6449 | .6446 | .6443 | .6440 | .6437 | .6434 | .6431 | .6428 | .6425 |
| | 5.370 | 5.367 | 5.365 | 5.362 | 5.360 | 5.357 | 5.355 | 5.352 | 5.350 | 5.347 |
| 88 | .6422 | .6419 | .6416 | .6413 | .6410 | .6407 | .6404 | .6401 | .6399 | .6396 |
| | 5.345 | 5.343 | 5.340 | 5.338 | 5.335 | 5.333 | 5.330 | 5.328 | 5.325 | 5.323 |
| 89 | .6393 | .6390 | .6387 | .6384 | .6391 | .6378 | .6375 | .6372 | .6369 | .6367 |
| | 5.320 | 5.318 | 5.316 | 5.313 | 5.311 | 5.308 | 5.306 | 5.304 | 5.301 | 5.299 |
| 90 | .6364 | .6361 | .6358 | .6355 | .6352 | .6349 | .6346 | .6343 | .6341 | .6338 |
| | 5.296 | 5.294 | 5.291 | 5.289 | 5.286 | 5.284 | 5.281 | 5.279 | 5.277 | 5.275 |
| 91 | .6335 | .6332 | .6329 | .6326 | .6323 | .6321 | .6318 | .6315 | .6312 | .6309 |
| | 5.272 | 5.270 | 5.267 | 5.265 | 5.263 | 5.261 | 5.258 | 5.256 | 5.253 | 5.251 |
| 92 | .6306 | .6303 | .6301 | .6298 | .6295 | .6292 | .6289 | .6286 | .6284 | .6281 |
| | 5.248 | 5.246 | 5.214 | 5.241 | 5.239 | 5.236 | 5.234 | 5.232 | 5.230 | 5.227 |
| 93 | .6278 | .6275 | .6272 | .6270 | .6267 | .6264 | .6261 | .6258 | .6256 | .6253 |
| | 5.225 | 5.222 | 5.220 | 5.218 | 5.216 | 5.213 | 5.210 | 5.208 | 5.206 | 5.204 |
| 94 | .6250 | .6247 | .6214 | .6242 | .6239 | .6236 | .6233 | .6231 | .6228 | .6225 |
| | 5.201 | 5.199 | 5.196 | 5.194 | 5.192 | 5.190 | 5.187 | 5.185 | 5.183 | 5.180 |
| 95 | .6222 | .6219 | .6217 | .6214 | .6211 | .6208 | .6206 | .6203 | .6200 | .6197 |
| | 5.178 | 5.176 | 5.174 | 5.171 | 5.169 | 5.166 | 5.164 | 5.162 | 5.160 | 5.157 |
| 96 | .6195 | .6192 | .6189 | .6186 | .6184 | .6181 | .6178 | .6176 | .6173 | .6170 |
| | 5.155 | 5.153 | 5.150 | 5.148 | 5.146 | 5.144 | 5.142 | 5.140 | 5.137 | 5.135 |
| 97 | .6167 | .6165 | .6162 | .6159 | .6157 | .6154 | .6151 | .6148 | .6146 | .6143 |
| | 5.132 | 5.130 | 5.128 | 5.126 | 5.124 | 5.121 | 5.119 | 5.116 | 5.114 | 5.112 |
| 98 | .6140 | .6138 | .6135 | .6132 | .6130 | .6127 | .6124 | .6122 | .6119 | .6116 |
| | 5.110 | 5.108 | 5.106 | 5.103 | 5.101 | 5.099 | 5.096 | 5.094 | 5.092 | 5.090 |
| 99 | .6114 | .6111 | .6108 | .6106 | .6103 | .6100 | .6098 | .6095 | .6092 | .6090 |
| | 5.088 | 5.085 | 5.083 | 5.081 | 5.079 | 5.076 | 5.074 | 5.072 | 5.070 | 5.068 |
| 100 | .6087 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| | 5.066 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |

## BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON.
## (MODULUS 141.5 TAGLIABUE.)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1.0000 | .9993 | .9986 | .9979 | .9972 | .9965 | .9958 | .9951 | .9944 | .9937 |
| | 8.331 | 8.325 | 8.319 | 8.314 | 8.308 | 8.302 | 8.296 | 8.290 | 8.284 | 8.279 |
| 11 | .9930 | .9923 | .9916 | .9909 | .9902 | .9895 | .9888 | .9881 | .9874 | .9868 |
| | 8.273 | 8.267 | 8.261 | 8.255 | 8.249 | 8.244 | 8.238 | 8.232 | 8.226 | 8.221 |
| 12 | .9861 | .9854 | .9847 | .9840 | .9833 | .9826 | .9820 | .9813 | .9806 | .9799 |
| | 8.215 | 8.209 | 8.204 | 8.198 | 8.192 | 8.186 | 8.181 | 8.175 | 8.169 | 8.164 |
| 13 | .9792 | .9786 | .9779 | .9772 | .9765 | .9759 | .9752 | .9745 | .9738 | .9732 |
| | 8.158 | 8.153 | 8.147 | 8.141 | 8.135 | 8.130 | 8.124 | 8.119 | 8.113 | 8.108 |
| 14 | .9725 | .9718 | .9712 | .9705 | .9698 | .9692 | .9685 | .9679 | .9672 | .9665 |
| | 8.102 | 8.096 | 8.091 | 8.085 | 8.079 | 8.074 | 8.069 | 8.064 | 8.058 | 8.052 |
| 15 | .9659 | .9652 | .9646 | .9639 | .9632 | .9626 | .9619 | .9613 | .9606 | .9600 |
| | 8.047 | 8.041 | 8.036 | 8.030 | 8.024 | 8.019 | 8.014 | 8.009 | 8.003 | 7.998 |
| 16 | .9593 | .9587 | .9580 | .9574 | .9567 | .9561 | .9554 | .9548 | .9542 | .9535 |
| | 7.992 | 7.987 | 7.981 | 7.976 | 7.970 | 7.965 | 7.959 | 7.954 | 7.949 | 7.944 |
| 17 | .9529 | .9522 | .9516 | .9509 | .9503 | .9497 | .9490 | .9484 | .9478 | .9471 |
| | 7.939 | 7.933 | 7.928 | 7.922 | 7.917 | 7.912 | 7.906 | 7.901 | 7.896 | 7.890 |
| 18 | .9465 | .9159 | .9452 | .9446 | .9440 | .9433 | .9427 | .9421 | .9415 | .9408 |
| | 7.885 | 7.880 | 7.874 | 7.869 | 7.864 | 7.859 | 7.854 | 7.849 | 7.844 | 7.838 |
| 19 | .9402 | .9396 | .9390 | .9383 | .9377 | .9371 | .9365 | .9359 | .9352 | .9346 |
| | 7.833 | 7.828 | 7.823 | 7.817 | 7.812 | 7.807 | 7.802 | 7.797 | 7.791 | 7.786 |
| 20 | .9340 | .9334 | .9328 | .9322 | .9315 | .9309 | .9303 | .9297 | .9291 | .9285 |
| | 7.781 | 7.776 | 7.771 | 7.766 | 7.760 | 7.755 | 7.750 | 7.745 | 7.740 | 7.735 |
| 21 | .9279 | .9273 | .9267 | .9260 | .9254 | .9248 | .9242 | .9236 | .9230 | .9224 |
| | 7.730 | 7.725 | 7.720 | 7.715 | 7.710 | 7.705 | 7.700 | 7.695 | 7.690 | 7.685 |
| 22 | .9218 | .9212 | .9206 | .9200 | .9194 | .9188 | .9182 | .9176 | .9170 | .9165 |
| | 7.680 | 7.675 | 7.670 | 7.665 | 7.660 | 7.655 | 7.650 | 7.645 | 7.640 | 7.635 |
| 23 | .9159 | .9153 | .9147 | .9141 | .9135 | .9129 | .9123 | .9117 | .9111 | .9106 |
| | 7.630 | 7.625 | 7.620 | 7.615 | 7.610 | 7.605 | 7.600 | 7.595 | 7.590 | 7.586 |
| 24 | .9100 | .9094 | .9088 | .9082 | .9076 | .9071 | .9065 | .9059 | .9053 | .9047 |
| | 7.581 | 7.576 | 7.571 | 7.566 | 7.561 | 7.557 | 7.552 | 7.547 | 7.542 | 7.537 |
| 25 | .9042 | .9036 | .9030 | .9024 | .9018 | .9013 | .9007 | .9001 | .8996 | .8990 |
| | 7.533 | 7.528 | 7.523 | 7.518 | 7.513 | 7.509 | 7.504 | 7.499 | 7.495 | 7.490 |
| 26 | .8984 | .8978 | .8973 | .8967 | .8961 | .8956 | .8950 | .8944 | .8939 | .8933 |
| | 7.485 | 7.480 | 7.475 | 7.471 | 7.465 | 7.461 | 7.456 | 7.451 | 7.447 | 7.442 |
| 27 | .8827 | .8922 | .8916 | .8911 | .8905 | .8899 | .8894 | .8888 | .8883 | .8877 |
| | 7.437 | 7.433 | 7.428 | 7.424 | 7.419 | 7.414 | 7.410 | 7.405 | 7.400 | 7.395 |
| 28 | .8871 | .8866 | .8860 | .8855 | .8849 | .8844 | .8838 | .8833 | .8827 | .8822 |
| | 7.390 | 7.386 | 7.381 | 7.377 | 7.372 | 7.368 | 7.363 | 7.359 | 7.354 | 7.350 |
| 29 | .8816 | .8811 | .8805 | .8800 | .8794 | .8789 | .8783 | .8778 | .8772 | .8767 |
| | 7.345 | 7.340 | 7.335 | 7.331 | 7.326 | 7.322 | 7.318 | 7.313 | 7.308 | 7.304 |
| 30 | .8762 | .8756 | .8751 | .8745 | .8740 | .8735 | .8729 | .8724 | .8718 | .8713 |
| | 7.300 | 7.295 | 7.290 | 7.285 | 7.281 | 7.277 | 2.272 | 7.268 | 7.263 | 7.259 |
| 31 | .8708 | .8702 | .8697 | .8692 | .8686 | .8681 | .8676 | .8670 | .8665 | .8660 |
| | 7.255 | 7.250 | 7.245 | 7.241 | 7.236 | 7.232 | 7.228 | 7.223 | 7.219 | 7.215 |
| 32 | .8654 | .8649 | .8644 | .8639 | .8633 | .8628 | .8623 | .8618 | .8612 | .8607 |
| | 7.210 | 7.205 | 7.201 | 7.197 | 7.192 | 7.188 | 7.184 | 7.180 | 7.175 | 7.170 |
| 33 | .8602 | .8597 | .8591 | .8586 | .8581 | .8576 | .8571 | .8565 | .8560 | .8555 |
| | 7.166 | 7.162 | 7.157 | 7.153 | 7.149 | 7.145 | 7.141 | 7.136 | 7.131 | 7.127 |
| 34 | .8550 | .8545 | .8540 | .8534 | .8529 | .8524 | .8519 | .8514 | .8509 | .8504 |
| | 7.123 | 7.119 | 7.115 | 7.110 | 7.106 | 7.101 | 7.097 | 7.093 | 7.089 | 7.085 |
| 35 | .8498 | .8493 | .8488 | .8483 | .8478 | .8473 | .8468 | .8463 | .8458 | .8453 |
| | 7.080 | 7.076 | 7.071 | 7.067 | 7.063 | 7.059 | 7.055 | 7.051 | 7.046 | 7.042 |
| 36 | .8448 | .8443 | .8438 | .8433 | .8428 | .8423 | .8418 | .8413 | .8408 | .8403 |
| | 7.038 | 7.034 | 7.030 | 7.026 | 7.021 | 7.017 | 7.013 | 7.009 | 7.005 | 7.001 |
| 37 | .8398 | .8393 | .8388 | .8383 | .8378 | .8373 | .8368 | .8363 | .8358 | .8353 |
| | 6.996 | 6.992 | 6.988 | 6.984 | 6.980 | 6.976 | 6.971 | 6.967 | 6.963 | 6.959 |
| 38 | .8348 | .8343 | .8338 | .8333 | .8328 | .8324 | .8319 | .8314 | .8309 | .8304 |
| | 6.955 | 6.951 | 6.946 | 6.942 | 6.938 | 6.935 | 6.931 | 6.926 | 6.922 | 6.918 |

## BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
(MODULUS 141.5.)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 39 | .8299 | .8294 | .8289 | .8285 | .8280 | .8275 | .8270 | .8265 | .8260 | .8256 |
| | 6.914 | 6.910 | 6.906 | 6.902 | 6.898 | 6.894 | 6.890 | 6.886 | 6.881 | 6.878 |
| 40 | .8251 | .8246 | .8241 | .8236 | .8232 | .8227 | .8222 | .8217 | .8212 | .8208 |
| | 6.874 | 6.870 | 6.866 | 6.861 | 6.858 | 6.854 | 6.850 | 6.846 | 6.841 | 6.838 |
| 41 | .8203 | .8198 | .8193 | .8189 | .8184 | .8179 | .8174 | .8170 | .8165 | .8160 |
| | 6.834 | 6.830 | 6.826 | 6.822 | 6.818 | 6.814 | 6.810 | 6.806 | 6.802 | 6.798 |
| 42 | .8156 | .8151 | .8146 | .8142 | .8137 | .8132 | .8128 | .8123 | .8118 | .8114 |
| | 6.795 | 6.791 | 6.786 | 6.783 | 6.779 | 6.775 | 6.771 | 6.767 | 6.763 | 6.760 |
| 43 | .8109 | .8104 | .8100 | .8095 | .8090 | .8086 | .8081 | .8076 | .8072 | .8067 |
| | 6.756 | 6.751 | 6.748 | 6.744 | 6.740 | 6.736 | 6.732 | 6.728 | 6.725 | 6.721 |
| 44 | .8063 | .8058 | .8053 | .8049 | .8044 | .8040 | .8035 | .8031 | .8026 | .8022 |
| | 6.717 | 6.713 | 6.709 | 6.706 | 6.701 | 6.698 | 6.694 | 6.691 | 6.868 | 6.683 |
| 45 | .8017 | .8012 | .8008 | .8003 | .7999 | .7994 | .7990 | .7985 | .9781 | .7976 |
| | 6.679 | 6.675 | 6.671 | 6.667 | 6.664 | 6.660 | 6.656 | 6.652 | 6.649 | 6.645 |
| 46 | .7972 | .7967 | .7963 | .7958 | .7954 | .7949 | .7945 | .7941 | .7936 | .7932 |
| | 6.641 | 6.637 | 6.634 | 6.630 | 6.626 | 6.623 | 6.619 | 6.616 | 6.611 | 6.608 |
| 47 | .7927 | .7923 | .7918 | .7914 | .7909 | .7905 | .7901 | .7896 | .7892 | .7887 |
| | 6.604 | 6.601 | 6.596 | 6.593 | 6.589 | 6.586 | 6.582 | 6.578 | 6.575 | 6.571 |
| 48 | .7883 | .7879 | .7874 | .7870 | .7865 | .7861 | .7857 | .7852 | .7848 | .7844 |
| | 6.567 | 6.564 | 6.560 | 6.556 | 6.552 | 6.549 | 6.546 | 6.542 | 6.538 | 6.535 |
| 49 | .7839 | .7835 | .7831 | .7826 | .7822 | .7818 | .7813 | .7809 | .7805 | .7800 |
| | 6.531 | 6.527 | 6.524 | 6.520 | 6.517 | 6.513 | 6.500 | 6.506 | 6.502 | 6.498 |
| 50 | .7796 | .7792 | .7788 | .7783 | .7779 | .7775 | .7770 | .7766 | .7762 | .7758 |
| | 6.495 | 6.492 | 6.488 | 6.484 | 6.481 | 6.477 | 6.473 | 6.470 | 6.467 | 6.463 |
| 51 | .7753 | .7749 | .7745 | .7741 | .7736 | .7732 | .7728 | .7724 | .7720 | .7715 |
| | 6.459 | 6.456 | 6.452 | 6.449 | 6.445 | 6.442 | 6.438 | 6.435 | 6.432 | 6.427 |
| 52 | .7711 | .7707 | .7703 | .7699 | .7694 | .7690 | .7686 | .7682 | .7678 | .7674 |
| | 6.424 | 6.421 | 6.417 | 6.414 | 6.410 | 6.407 | 6.403 | 6.400 | 6.397 | 6.393 |
| 53 | .7669 | .7665 | .7661 | .7657 | .7653 | .7649 | .7645 | .7640 | .7636 | .7632 |
| | 6.389 | 6.386 | 6.382 | 6.379 | 6.376 | 6.372 | 6.369 | 6.365 | 6.362 | 6.358 |
| 54 | .7628 | .7624 | .7620 | .7616 | .7612 | .7608 | .7603 | .7599 | .7595 | .7591 |
| | 6.355 | 6.352 | 6.348 | 6.345 | 6.342 | 6.338 | 6.334 | 6.331 | 6.327 | 6.324 |
| 55 | .7587 | .7583 | .7579 | .7575 | .7571 | .7567 | .7563 | .7559 | .7555 | .7551 |
| | 6.321 | 6.317 | 6.314 | 6.311 | 6.307 | 6.304 | 6.301 | 6.297 | 6.294 | 6.291 |
| 56 | .7547 | .7543 | .7539 | .7535 | .7531 | .7527 | .7523 | .7519 | .7515 | .7511 |
| | 6.287 | 6.284 | 6.281 | 6.277 | 6.274 | 6.271 | 6.267 | 6.264 | 6.261 | 6.257 |
| 57 | .7507 | .7503 | .7499 | .7495 | .7491 | .7487 | .7483 | .7479 | .7475 | .7471 |
| | 6.254 | 6.251 | 6.247 | 6.244 | 6.241 | 6.237 | 6.234 | 6.231 | 6.227 | 6.224 |
| 58 | .7467 | .7463 | .7459 | .7455 | .7451 | .7447 | .7443 | .7440 | .7436 | .7432 |
| | 6.221 | 6.217 | 6.214 | 62.11 | 6.207 | 6.204 | 6.201 | 6.198 | 6.195 | 6.191 |
| 59 | .7428 | .7424 | .7420 | .7416 | .7412 | .7408 | .7405 | .7401 | .7397 | .7393 |
| | 6.188 | 6.185 | 6.182 | 6.178 | 6.175 | 6.172 | 6.169 | 6.166 | 6.162 | 6.159 |
| 60 | .7389 | .7385 | .7381 | .7377 | .7374 | .7370 | .7366 | .7362 | .7358 | .7354 |
| | 6.156 | 6.152 | 6.149 | 6.146 | 6.143 | 6.140 | 6.137 | 6.133 | 6.130 | 6.127 |
| 61 | .7351 | .7347 | .7343 | .7339 | .7335 | .7332 | .7328 | .7324 | .7320 | .7316 |
| | 6.124 | 6.121 | 6.117 | 6.114 | 6.111 | 6.108 | 6.105 | 6.102 | 6.098 | 6.095 |
| 62 | .7313 | .7309 | .7305 | .7301 | .7298 | .7294 | .7290 | .7286 | .7283 | .7279 |
| | 6.092 | 6.089 | 6.086 | 6.082 | 6.080 | 6.077 | 6.073 | 6.070 | 6.067 | 6.064 |
| 63 | .7275 | .7271 | .7268 | .7264 | .7260 | .7256 | .7253 | .7249 | .7245 | .7242 |
| | 6.061 | 6.057 | 6.055 | 6.052 | 6.048 | 6.045 | 6.042 | 6.039 | 6.036 | 6.033 |
| 64 | .7238 | .7234 | .7230 | .7227 | .7223 | .7219 | .7216 | .7212 | .7208 | .7205 |
| | 6.030 | 6.027 | 6.023 | 6.021 | 6.017 | 6.014 | 6.012 | 6.008 | 6.005 | 6.002 |
| 65 | .7201 | .7197 | .7194 | .7190 | .7186 | .7183 | .7179 | .7175 | .7172 | .7168 |
| | 5.999 | 5.996 | 5.993 | 5.990 | 5.987 | 5.984 | 5.981 | 5.977 | 5.975 | 5.972 |
| 66 | .7165 | .7161 | .7157 | .7154 | .7150 | .7146 | .7143 | .7139 | .7136 | .7132 |
| | 5.969 | 5.966 | 5.962 | 5.960 | 5.957 | 5.953 | 5.951 | 5.948 | 5.945 | 5.942 |
| 67 | .7128 | .7125 | .7121 | .7118 | .7114 | .7111 | .7107 | .7103 | .7100 | .7096 |
| | 5.938 | 5.936 | 5.933 | 5.930 | 5.927 | 5.924 | 5.921 | 5.918 | 5.915 | 5.912 |

## BAUME', SPECIFIC GRAVITY AND POUNDS PER GALLON—Con.
(MODULUS 141.5.)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 68 | .7093 | .7089 | .7086 | .7082 | .7079 | .7075 | .7071 | .7068 | .7064 | .7061 |
| | 5.909 | 5.906 | 5.903 | 5.900 | 5.898 | 5.894 | 5.891 | 5.888 | 5.885 | 5.883 |
| 69 | .7057 | .7054 | .7050 | .7047 | .7043 | .7040 | .7036 | .7033 | .7029 | .7026 |
| | 5.879 | 5.877 | 5.873 | 5.871 | 5.868 | 5.865 | 5.862 | 5.859 | 5.856 | 5.853 |
| 70 | .7022 | .7019 | .7015 | .7012 | .7008 | .7005 | .7001 | .6998 | .6995 | .6991 |
| | 5.850 | 5.848 | 5.844 | 5.842 | 5.838 | 5.836 | 5.833 | 5.830 | 5.828 | 5.824 |
| 71 | .6988 | .6984 | .6981 | .6977 | .6974 | .6970 | .6967 | .6964 | .6960 | .6957 |
| | 5.822 | 5.818 | 5.816 | 5.813 | 5.810 | 5.807 | 5.804 | 5.802 | 5.798 | 5.796 |
| 72 | .6953 | .6950 | .6946 | .6943 | .6940 | .6936 | .6933 | .6929 | .6926 | .6923 |
| | 5.793 | 5.790 | 5.787 | 5.784 | 5.782 | 5.778 | 5.776 | 5.773 | 5.770 | 5.768 |
| 73 | .6919 | .6916 | .6912 | .6909 | .6906 | .6902 | .6899 | .6896 | .6892 | .6889 |
| | 5.764 | 5.762 | 5.758 | 5.756 | 5.753 | 5.750 | 5.748 | 5.745 | 5.742 | 5.739 |
| 74 | .6886 | .6882 | .6879 | .6876 | .6872 | .6869 | .6866 | .6862 | .6859 | .6856 |
| | 5.737 | 5.733 | 5.731 | 5.728 | 5.725 | 5.723 | 5.720 | 5.717 | 5.714 | 5.712 |
| 75 | .6852 | .6849 | .6846 | .6842 | .6839 | .6836 | .6832 | .6829 | .6826 | .6823 |
| | 5.708 | 5.706 | 5.703 | 5.700 | 5.698 | 5.695 | 5.692 | 5.689 | 5.687 | 5.684 |
| 76 | .6819 | .6816 | 6813 | .6809 | .6806 | .6803 | .6800 | .6796 | .6793 | .6790 |
| | 5.681 | 5.678 | 5.676 | 5.673 | 5.670 | 5.668 | 5.665 | 5.662 | 5.659 | 5.657 |
| 77 | .6787 | .6783 | .6780 | .6777 | .6774 | .6770 | .6767 | .6764 | .6761 | .6757 |
| | 5.654 | 5.651 | 5.648 | 5.646 | 5.643 | 5.640 | 5.638 | 5.635 | 5.633 | 5.629 |
| 78 | .6754 | .6751 | .6748 | .6745 | .6741 | .6738 | .6735 | .6732 | .6728 | .6725 |
| | 5.627 | 5.624 | 5.622 | 5.619 | 5.616 | 5.613 | 5.611 | 5.608 | 5.605 | 5.603 |
| 79 | .6722 | .6719 | .6716 | .6713 | .6709 | .6706 | .6703 | .6700 | .6697 | .6693 |
| | 5.600 | 5.597 | 5.595 | 5.593 | 5.589 | 5.587 | 5.584 | 5.582 | 5.579 | 5.576 |
| 80 | .6690 | .6687 | .6684 | .6681 | .6678 | .6675 | .6671 | .6668 | .6665 | .6662 |
| | 5.573 | 5.571 | 5.568 | 5.566 | 5.563 | 5.561 | 5.558 | 5.555 | 5.553 | 5.550 |
| 81 | .6659 | .6656 | .6653 | .6649 | .6646 | .6643 | .6640 | .6637 | .6634 | .6631 |
| | 5.548 | 5.545 | 5.543 | 5.540 | 5.537 | 5.534 | 5.532 | 5.529 | 5.527 | 5.524 |
| 82 | .6628 | .6625 | .6621 | .6618 | .6615 | .6612 | .6609 | .6606 | .6603 | .6600 |
| | 5.522 | 5.519 | 5.516 | 5.513 | 5.511 | 5.508 | 5.506 | 5.503 | 5.501 | 5.498 |
| 83 | .6597 | .6594 | .6591 | .6588 | .6584 | .6581 | .6578 | .6575 | .6572 | .6569 |
| | 5.496 | 5.493 | 5.491 | 5.488 | 5.485 | 5.483 | 5.480 | 5.478 | 5.475 | 5.473 |
| 84 | .6566 | .6563 | .6560 | .6557 | .6554 | .6551 | .6548 | .6545 | .6542 | .6539 |
| | 5.470 | 5.468 | 5.465 | 5.463 | 5.460 | 5.458 | 5.455 | 5.453 | 5.450 | 5.448 |
| 85 | .6536 | .6533 | .6530 | .6527 | .6524 | .6521 | .6518 | .6515 | .6512 | .6509 |
| | 5.445 | 5.443 | 5.440 | 5.438 | 5.435 | 5.433 | 5.430 | 5.428 | 5.425 | 5.423 |
| 86 | .6506 | .6503 | .6500 | .6497 | .6494 | .6491 | .6488 | .6485 | .6482 | .6479 |
| | 5.420 | 5.418 | 5.415 | 5.419 | 5.410 | 5.408 | 5.405 | 5.403 | 5.400 | 5.398 |
| 87 | .6476 | .6473 | .6470 | .6467 | .6464 | .6461 | .6458 | .6455 | .6452 | .6449 |
| | 5.395 | 5.393 | 5.390 | 5.388 | 5.385 | 5.383 | 5.380 | 5.378 | 5.375 | 5.373 |
| 88 | .6446 | .6444 | .6441 | .6438 | .6435 | .6432 | .6429 | .6426 | .6423 | .6420 |
| | 5.370 | 5.368 | 5.366 | 5.363 | 5.361 | 5.358 | 5.356 | 5.353 | 5.351 | 5.349 |
| 89 | .6417 | .6414 | .6411 | .6409 | .6406 | .6403 | .6400 | .6397 | .6394 | .6391 |
| | 5.346 | 5.344 | 5.341 | 5.339 | 5.237 | 5.334 | 5.332 | 5.329 | 5.327 | 5.324 |
| 90 | .6388 | .6385 | .6382 | .6380 | .6377 | .6374 | .6371 | .6368 | .6365 | .6362 |
| | 5.322 | 5.319 | 5.317 | 5.315 | 5.313 | 5.310 | 5.308 | 5.305 | 5.303 | 5.300 |
| 91 | .6360 | .6357 | .6354 | .6351 | .6348 | .6345 | .6342 | .6340 | .6337 | .6334 |
| | 5.299 | 5.296 | 5.294 | 5.291 | 5.289 | 5.286 | 5.284 | 5.282 | 5.279 | 5.277 |
| 92 | .6331 | .6328 | .6325 | .6323 | .6320 | .6317 | .6314 | .6311 | .6309 | .6306 |
| | 5.274 | 5.272 | 5.269 | 5.268 | 5.265 | 5.263 | 5.260 | 5.258 | 5.256 | 5.254 |
| 93 | .6303 | .6300 | .6297 | .6294 | .6292 | .6289 | .6286 | .6283 | .6281 | .6278 |
| | 5.251 | 5.249 | 5.246 | 5.244 | 5.242 | 5.239 | 5.237 | 5.234 | 5.233 | 5.230 |
| 94 | .6275 | .6272 | .6269 | .6267 | .6264 | .6261 | .6258 | .6256 | .6253 | .6250 |
| | 5.228 | 5.225 | 5.223 | 5.221 | 5.219 | 5.216 | 5.214 | 5.212 | 5.209 | 5.207 |
| 95 | .6247 | .6244 | .6242 | .6239 | .6236 | .6233 | .6231 | .6228 | .6225 | .6223 |
| | 5.204 | 5.202 | 5.200 | 5.198 | 5.195 | 5.193 | 5.191 | 5.189 | 5.186 | 5.184 |
| 96 | .6220 | .6217 | .6214 | .6212 | .6209 | .6206 | .6203 | .6201 | .6198 | .6195 |
| | 5.182 | 5.179 | 5.177 | 5.175 | 5.173 | 5.170 | 5.168 | 5.166 | 5.164 | 5.161 |
| 97 | .6193 | .6190 | .6187 | .6184 | .6182 | .6179 | .6176 | .6174 | .6171 | .6168 |
| | 5.159 | 5.157 | 5.154 | 5.152 | 5.150 | 5.148 | 5.145 | 5.144 | 5.141 | 5.139 |
| 98 | .6166 | .6163 | .6160 | .6158 | .6155 | .6152 | .6150 | .6147 | .6144 | .6141 |
| | 5.137 | 5.134 | 5.132 | 5.130 | 5.128 | 5.125 | 5.124 | 5.121 | 5.119 | 5.116 |
| 99 | .6139 | .6136 | .6134 | .6131 | .6128 | .6126 | .6123 | .6120 | .6118 | .6115 |
| | 5.114 | 5.112 | 5.110 | 5.108 | 5.105 | 5.104 | 5.101 | 5.099 | 5.097 | 5.094 |

[This table shows the degrees Baumé at 60° F of oils having, at the designated temperatures, the observed degrees Baumé indicated. For example, if the observed degrees Baumé is 20.0 at 78° F, the true degrees Baumé at 60° F will be 19.0. Intermediate values not given in the table may be conveniently interpolated. For example, if the observed degrees Baumé is 20.4 at 78° F, the true degrees Baumé at 60° F will be 19.4. The headings "Observed degrees Baumé" and "Observed temperature" signify the true indication of the hydrometer and the true temperature of the oil—that is, the observed readings corrected, if necessary, for instrumental errors.]

| Observed temperature in ° F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 17.0 | 18.0 | 19.0 | 20.0 | 21.0 | 22.0 | 23.0 | 24.0 | 25.0 | 26.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 18.6 | 19.7 | 20.7 | 21.7 | 22.7 | 23.7 | 24.8 | 25.8 | 26.9 | 27.9 |
| 32 | 18.6 | 19.6 | 20.6 | 21.6 | 22.6 | 23.6 | 24.7 | 25.7 | 26.8 | 27.8 |
| 34 | 18.5 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.6 | 25.6 | 26.7 | 27.7 |
| 36 | 18.3 | 19.4 | 20.4 | 21.4 | 22.4 | 23.4 | 24.5 | 25.5 | 26.5 | 27.5 |
| 38 | 18.2 | 19.3 | 20.3 | 21.3 | 22.3 | 23.3 | 24.4 | 25.4 | 26.4 | 27.4 |
| 40 | 18.1 | 19.1 | 20.1 | 21.2 | 22.2 | 23.2 | 24.2 | 25.2 | 26.2 | 27.2 |
| 42 | 18.0 | 19.0 | 20.0 | 21.1 | 22.1 | 23.1 | 24.1 | 25.1 | 26.1 | 27.1 |
| 44 | 17.9 | 18.9 | 19.9 | 20.9 | 21.9 | 22.9 | 23.9 | 24.9 | 26.0 | 27.0 |
| 46 | 17.8 | 18.8 | 19.8 | 20.8 | 21.8 | 22.8 | 23.8 | 24.8 | 25.9 | 26.9 |
| 48 | 17.6 | 18.7 | 19.7 | 20.7 | 21.7 | 22.7 | 23.7 | 24.7 | 25.8 | 26.8 |
| 50 | 17.5 | 18.6 | 19.6 | 20.6 | 21.6 | 22.6 | 23.6 | 24.6 | 25.6 | 26.6 |
| 52 | 17.4 | 18.5 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.5 | 25.5 | 26.5 |
| 54 | 17.3 | 18.3 | 19.3 | 20.3 | 21.3 | 22.3 | 23.3 | 24.3 | 25.4 | 26.4 |
| 56 | 17.2 | 18.2 | 19.2 | 20.2 | 21.2 | 22.2 | 23.2 | 24.2 | 25.3 | 26.3 |
| 58 | 17.1 | 18.1 | 19.1 | 20.1 | 21.1 | 22.1 | 23.1 | 24.1 | 25.1 | 26.1 |
| 60 | 17.0 | 18.0 | 19.0 | 20.0 | 21.0 | 22.0 | 23.0 | 24.0 | 25.0 | 26.0 |
| 62 | ........ | 17.9 | 18.9 | 19.9 | 20.9 | 21.9 | 22.9 | 23.9 | 24.9 | 25.9 |
| 64 | ........ | 17.8 | 18.8 | 19.8 | 20.8 | 21.8 | 22.8 | 23.8 | 24.7 | 25.7 |
| 66 | ........ | 17.7 | 18.7 | 19.7 | 20.7 | 21.7 | 22.7 | 23.7 | 24.6 | 25.6 |
| 68 | ........ | 17.6 | 18.6 | 19.5 | 20.5 | 21.5 | 22.5 | 23.5 | 24.5 | 25.5 |
| 70 | ........ | 17.5 | 18.5 | 19.4 | 20.4 | 21.4 | 22.4 | 23.4 | 24.4 | 25.4 |
| 72 | ........ | 17.4 | 18.4 | 19.3 | 20.3 | 21.3 | 22.3 | 23.3 | 24.3 | 25.3 |
| 74 | ........ | 17.2 | 18.2 | 19.2 | 20.2 | 21.2 | 22.2 | 23.2 | 24.1 | 25.1 |
| 76 | ........ | 17.2 | 18.1 | 19.1 | 20.1 | 21.1 | 22.1 | 23.1 | 24.0 | 25.0 |
| 78 | ........ | 17.1 | 18.0 | 19.0 | 19.9 | 20.9 | 21.9 | 22.9 | 23.9 | 24.9 |
| 80 | ........ | ........ | 17.9 | 18.9 | 19.8 | 20.8 | 21.8 | 22.8 | 23.8 | 24.8 |
| 82 | ........ | ........ | 17.8 | 18.8 | 19.7 | 20.7 | 21.7 | 22.7 | 23.7 | 24.7 |
| 84 | ........ | ........ | 17.7 | 18.7 | 19.6 | 20.6 | 21.6 | 22.6 | 23.5 | 24.5 |
| 86 | ........ | ........ | 17.6 | 18.6 | 19.5 | 20.5 | 21.5 | 22.5 | 23.4 | 24.4 |
| 88 | ........ | ........ | 17.5 | 18.4 | 19.4 | 20.4 | 21.3 | 22.3 | 23.3 | 24.3 |
| 90 | ........ | ........ | 17.3 | 18.3 | 19.3 | 20.3 | 21.2 | 22.2 | 23.2 | 24.2 |
| 92 | ........ | ........ | 17.2 | 18.2 | 19.2 | 20.2 | 21.1 | 22.1 | 23.1 | 24.1 |
| 94 | ........ | ........ | 17.1 | 18.1 | 19.1 | 20.1 | 21.0 | 22.0 | 23.0 | 24.0 |
| 96 | ........ | ........ | 17.0 | 18.0 | 19.0 | 20.0 | 20.9 | 21.9 | 22.8 | 23.8 |
| 98 | ........ | ........ | ........ | 17.9 | 18.8 | 19.8 | 20.8 | 21.8 | 22.7 | 23.7 |
| 100 | ........ | ........ | ........ | 17.8 | 18.7 | 19.7 | 20.7 | 21.7 | 22.6 | 23.6 |
| 102 | ........ | ........ | ........ | 17.7 | 18.6 | 19.6 | 20.5 | 21.5 | 22.5 | 23.5 |
| 104 | ........ | ........ | ........ | 17.6 | 18.5 | 19.5 | 20.4 | 21.4 | 22.4 | 23.4 |
| 106 | ........ | ........ | ........ | 17.5 | 18.4 | 19.4 | 20.3 | 21.3 | 22.3 | 23.3 |
| 108 | ........ | ........ | ........ | 17.3 | 18.2 | 19.2 | 20.2 | 21.2 | 22.2 | 23.1 |
| 110 | ........ | ........ | ........ | 17.2 | 18.1 | 19.1 | 20.1 | 21.1 | 22.0 | 23.0 |
| 112 | ........ | ........ | ........ | 17.1 | 18.0 | 19.0 | 20.0 | 21.0 | 21.9 | 22.9 |
| 114 | ........ | ........ | ........ | 17.0 | 17.9 | 18.9 | 19.9 | 20.9 | 21.8 | 22.8 |
| 116 | ........ | ........ | ........ | ........ | 17.8 | 18.8 | 19.8 | 20.8 | 21.7 | 22.7 |
| 118 | ........ | ........ | ........ | ........ | 17.7 | 18.7 | 19.6 | 20.6 | 21.5 | 22.5 |
| 120 | ........ | ........ | ........ | ........ | 17.6 | 18.6 | 19.5 | 20.5 | 21.4 | 22.4 |

| Observed temperature in ° F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 27.0 | 28.0 | 29.0 | 30.0 | 31.0 | 32.0 | 33.0 | 34.0 | 35.0 | 36.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 29.0 | 30.0 | 31.0 | 32.0 | 33.1 | 34.1 | 35.2 | 36.2 | 37.3 | 38.3 |
| 32 | 28.8 | 29.8 | 30.9 | 31.9 | 33.0 | 34.0 | 35.0 | 36.0 | 37.1 | 38.1 |
| 34 | 28.7 | 29.7 | 30.8 | 31.8 | 32.8 | 33.8 | 34.8 | 35.8 | 36.9 | 38.0 |
| 36 | 28.5 | 29.5 | 30.6 | 31.6 | 32.7 | 33.7 | 34.7 | 35.7 | 36.8 | 37.8 |
| 38 | 28.4 | 29.4 | 30.5 | 31.5 | 32.5 | 33.5 | 34.5 | 35.5 | 36.6 | 37.7 |
| 40 | 28.3 | 29.3 | 30.4 | 31.4 | 32.4 | 33.4 | 34.4 | 35.4 | 36.5 | 37.5 |
| 42 | 28.2 | 29.2 | 30.2 | 31.2 | 32.2 | 33.2 | 34.3 | 35.3 | 36.3 | 37.3 |
| 44 | 28.1 | 29.1 | 30.1 | 31.1 | 32.1 | 33.1 | 34.2 | 35.2 | 36.2 | 37.2 |
| 46 | 27.9 | 28.9 | 29.9 | 30.9 | 31.9 | 32.9 | 34.0 | 35.0 | 36.1 | 37.1 |
| 48 | 27.8 | 28.8 | 29.8 | 30.8 | 31.8 | 32.8 | 33.9 | 34.9 | 35.9 | 36.9 |
| 50 | 27.6 | 28.6 | 29.7 | 30.7 | 31.7 | 32.7 | 33.7 | 34.7 | 35.7 | 36.7 |
| 52 | 27.5 | 28.5 | 29.6 | 30.6 | 31.6 | 32.6 | 33.6 | 34.6 | 35.6 | 36.6 |
| 54 | 27.4 | 28.4 | 29.4 | 30.4 | 31.4 | 32.4 | 33.4 | 34.4 | 35.4 | 36.4 |
| 56 | 27.3 | 28.3 | 29.3 | 30.3 | 31.3 | 32.3 | 33.3 | 34.3 | 35.3 | 36.3 |
| 58 | 27.1 | 28.1 | 29.1 | 30.1 | 31.1 | 32.1 | 33.1 | 34.1 | 35.1 | 36.1 |
| 60 | 27.0 | 28.0 | 29.0 | 30.0 | 31.0 | 32.0 | 33.0 | 34.0 | 35.0 | 36.0 |
| 62 | 26.9 | 27.9 | 28.9 | 29.9 | 30.9 | 31.9 | 32.9 | 33.9 | 34.9 | 35.9 |
| 64 | 26.7 | 27.7 | 28.7 | 29.7 | 30.7 | 31.7 | 32.7 | 33.7 | 34.7 | 35.7 |
| 66 | 26.6 | 27.6 | 28.6 | 29.6 | 30.6 | 31.6 | 32.6 | 33.6 | 34.6 | 35.6 |
| 68 | 26.5 | 27.5 | 28.4 | 29.4 | 30.4 | 31.4 | 32.4 | 33.4 | 34.4 | 35.4 |
| 70 | 26.4 | 27.4 | 28.3 | 29.3 | 30.3 | 31.3 | 32.2 | 33.2 | 34.2 | 35.2 |
| 72 | 26.3 | 27.3 | 28.2 | 29.2 | 30.2 | 31.2 | 32.1 | 33.1 | 34.1 | 35.1 |
| 74 | 26.1 | 27.1 | 28.1 | 29.1 | 30.1 | 31.1 | 32.0 | 33.0 | 33.9 | 34.9 |
| 76 | 26.0 | 27.0 | 27.9 | 28.9 | 29.9 | 30.9 | 31.8 | 32.8 | 33.8 | 34.8 |
| 78 | 25.8 | 26.8 | 27.8 | 28.8 | 29.8 | 30.8 | 31.7 | 32.7 | 33.6 | 34.6 |
| 80 | 25.7 | 26.7 | 27.7 | 28.7 | 29.7 | 30.7 | 31.6 | 32.6 | 33.5 | 34.5 |
| 82 | 25.6 | 26.6 | 27.6 | 28.6 | 29.5 | 30.5 | 31.5 | 32.5 | 33.4 | 34.4 |
| 84 | 25.5 | 26.5 | 27.5 | 28.5 | 29.4 | 30.4 | 31.3 | 32.3 | 33.2 | 34.2 |
| 86 | 25.4 | 26.4 | 27.3 | 28.3 | 29.2 | 30.2 | 31.2 | 32.2 | 33.1 | 34.1 |
| 88 | 25.2 | 26.2 | 27.2 | 28.2 | 29.1 | 30.1 | 31.0 | 32.0 | 33.0 | 34.0 |
| 90 | 25.1 | 26.1 | 27.0 | 28.0 | 29.0 | 30.0 | 30.9 | 31.9 | 32.9 | 33.9 |
| 92 | 25.0 | 26.0 | 26.9 | 27.9 | 28.9 | 29.9 | 30.8 | 31.8 | 32.7 | 33.7 |
| 94 | 24.9 | 25.9 | 26.8 | 27.8 | 28.8 | 29.8 | 30.7 | 31.6 | 32.6 | 33.6 |
| 96 | 24.7 | 25.7 | 26.7 | 27.7 | 28.6 | 29.6 | 30.5 | 31.5 | 32.5 | 33.5 |
| 98 | 24.6 | 25.6 | 26.6 | 27.6 | 28.5 | 29.5 | 30.4 | 31.4 | 32.3 | 33.3 |
| 100 | 24.5 | 25.5 | 26.4 | 27.4 | 28.3 | 29.3 | 30.3 | 31.3 | 32.2 | 33.2 |
| 102 | 24.4 | 25.4 | 26.3 | 27.3 | 28.2 | 29.2 | 30.2 | 31.2 | 32.1 | 33.0 |
| 104 | 24.3 | 25.3 | 26.2 | 27.1 | 28.1 | 29.1 | 30.0 | 31.0 | 31.9 | 32.9 |
| 106 | 24.2 | 25.2 | 26.1 | 27.0 | 28.0 | 29.0 | 29.9 | 30.9 | 31.8 | 32.7 |
| 108 | 24.0 | 25.0 | 25.9 | 26.9 | 27.8 | 28.8 | 29.7 | 30.7 | 31.6 | 32.6 |
| 110 | 23.9 | 24.9 | 25.8 | 26.8 | 27.7 | 28.7 | 29.6 | 30.6 | 31.5 | 32.5 |
| 112 | 23.8 | 24.8 | 25.7 | 26.7 | 27.6 | 28.6 | 29.5 | 30.4 | 31.3 | 32.3 |
| 114 | 23.7 | 24.7 | 25.6 | 26.6 | 27.5 | 28.4 | 29.3 | 30.3 | 31.2 | 32.2 |
| 116 | 23.6 | 24.6 | 25.5 | 26.4 | 27.3 | 28.3 | 29.2 | 30.2 | 31.1 | 32.1 |
| 118 | 23.4 | 24.4 | 25.3 | 26.3 | 27.2 | 28.2 | 29.1 | 30.1 | 31.0 | 32.0 |
| 120 | 23.3 | 24.3 | 25.2 | 26.2 | 27.1 | 28.1 | 29.0 | 30.0 | 30.9 | 31.9 |

| Observed temperature in ° F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 37.0 | 38.0 | 39.0 | 40.0 | 41.0 | 42.0 | 43.0 | 44.0 | 45.0 | 46.0 |
| | Corresponding degrees Baume at 60° F | | | | | | | | | |
| 30 | 39.3 | 40.3 | 41.4 | 42.4 | 43.5 | 44.5 | 45.6 | 46.6 | 47.7 | 48.7 |
| 32 | 39.2 | 40.2 | 41.3 | 42.3 | 43.4 | 44.3 | 45.4 | 46.4 | 47.5 | 48.5 |
| 34 | 39.0 | 40.0 | 41.1 | 42.1 | 43.2 | 44.2 | 45.3 | 46.3 | 47.3 | 48.3 |
| 36 | 38.9 | 39.9 | 41.0 | 42.0 | 43.1 | 44.0 | 45.1 | 46.1 | 47.2 | 48.2 |
| 38 | 38.7 | 39.7 | 40.8 | 41.8 | 42.9 | 43.9 | 45.0 | 46.0 | 47.0 | 48.0 |
| 40 | 38.5 | 39.5 | 40.6 | 41.6 | 42.7 | 43.7 | 44.8 | 45.8 | 46.8 | 47.8 |
| 42 | 38.4 | 39.4 | 40.5 | 41.5 | 42.5 | 43.5 | 44.6 | 45.6 | 46.6 | 47.6 |
| 44 | 38.2 | 39.2 | 40.3 | 41.3 | 42.4 | 43.4 | 44.4 | 45.4 | 46.4 | 47.4 |
| 46 | 38.1 | 39.1 | 40.1 | 41.1 | 42.2 | 43.2 | 44.2 | 45.2 | 46.2 | 47.2 |
| 48 | 37.9 | 38.9 | 39.9 | 40.9 | 42.0 | 43.0 | 44.1 | 45.1 | 46.1 | 47.1 |
| 50 | 37.8 | 38.8 | 39.8 | 40.8 | 41.8 | 42.8 | 43.9 | 44.9 | 45.9 | 46.9 |
| 52 | 37.6 | 38.6 | 39.6 | 40.7 | 41.7 | 42.6 | 43.7 | 44.7 | 45.7 | 46.7 |
| 54 | 37.4 | 38.4 | 39.5 | 40.5 | 41.5 | 42.5 | 43.5 | 44.5 | 45.5 | 46.5 |
| 56 | 37.3 | 38.3 | 39.3 | 40.3 | 41.3 | 42.2 | 43.3 | 44.3 | 45.3 | 46.3 |
| 58 | 37.1 | 38.1 | 39.1 | 40.1 | 41.1 | 42.1 | 43.1 | 44.1 | 45.2 | 46.2 |
| 60 | 37.0 | 38.0 | 39.0 | 40.0 | 41.0 | 42.0 | 43.0 | 44.0 | 45.0 | 46.0 |
| 62 | 36.9 | 37.9 | 38.9 | 39.9 | 40.9 | 41.9 | 42.9 | 43.9 | 44.9 | 45.9 |
| 64 | 36.7 | 37.7 | 38.7 | 39.7 | 40.7 | 41.7 | 42.7 | 43.7 | 44.7 | 45.7 |
| 66 | 36.6 | 37.6 | 38.6 | 39.5 | 40.5 | 41.5 | 42.5 | 43.5 | 44.5 | 45.5 |
| 68 | 36.4 | 37.4 | 38.4 | 39.4 | 40.4 | 41.4 | 42.4 | 43.3 | 44.3 | 45.3 |
| 70 | 36.2 | 37.2 | 38.2 | 39.2 | 40.2 | 41.2 | 42.2 | 43.1 | 44.1 | 45.1 |
| 72 | 36.1 | 37.1 | 38.1 | 39.1 | 40.0 | 41.0 | 42.0 | 43.0 | 44.0 | 45.0 |
| 74 | 35.9 | 36.9 | 37.9 | 38.9 | 39.8 | 40.8 | 41.8 | 42.8 | 43.8 | 44.8 |
| 76 | 35.8 | 36.8 | 37.8 | 38.7 | 39.7 | 40.7 | 41.7 | 42.7 | 43.6 | 44.6 |
| 78 | 35.6 | 36.6 | 37.6 | 38.6 | 39.5 | 40.5 | 41.5 | 42.5 | 43.4 | 44.4 |
| 80 | 35.5 | 36.5 | 37.5 | 38.5 | 39.4 | 40.4 | 41.3 | 42.3 | 43.2 | 44.2 |
| 82 | 35.3 | 36.3 | 37.3 | 38.3 | 39.2 | 40.2 | 41.2 | 42.2 | 43.1 | 44.1 |
| 84 | 35.2 | 36.2 | 37.2 | 38.2 | 39.1 | 40.1 | 41.0 | 42.0 | 42.9 | 43.9 |
| 86 | 35.1 | 36.1 | 37.0 | 38.0 | 38.9 | 39.9 | 40.9 | 41.9 | 42.8 | 43.8 |
| 88 | 34.9 | 35.9 | 36.9 | 37.9 | 38.8 | 39.8 | 40.7 | 41.7 | 42.6 | 43.6 |
| 90 | 34.8 | 35.8 | 36.7 | 37.7 | 38.6 | 39.6 | 40.5 | 41.5 | 42.5 | 43.5 |
| 92 | 34.6 | 35.6 | 36.6 | 37.6 | 38.5 | 39.5 | 40.4 | 41.4 | 42.3 | 43.3 |
| 94 | 34.5 | 35.5 | 36.4 | 37.4 | 38.3 | 39.3 | 40.2 | 41.2 | 42.2 | 43.2 |
| 96 | 34.4 | 35.4 | 36.3 | 37.3 | 38.2 | 39.2 | 40.1 | 41.1 | 42.0 | 43.0 |
| 98 | 34.2 | 35.2 | 36.1 | 37.1 | 38.0 | 39.0 | 39.9 | 40.9 | 41.8 | 42.8 |
| 100 | 34.1 | 35.1 | 36.0 | 37.0 | 37.9 | 38.9 | 39.8 | 40.7 | 41.6 | 42.6 |
| 102 | 33.9 | 34.9 | 35.8 | 36.8 | 37.7 | 38.7 | 39.6 | 40.6 | 41.5 | 42.5 |
| 104 | 33.8 | 34.8 | 35.7 | 36.7 | 37.6 | 38.6 | 39.5 | 40.4 | 41.3 | 42.3 |
| 106 | 33.6 | 34.6 | 35.5 | 36.5 | 37.4 | 38.4 | 39.3 | 40.3 | 41.2 | 42.2 |
| 108 | 33.5 | 34.5 | 35.4 | 36.4 | 37.3 | 38.3 | 39.2 | 40.1 | 41.0 | 42.0 |
| 110 | 33.4 | 34.4 | 35.3 | 36.3 | 37.2 | 38.1 | 39.0 | 40.0 | 40.9 | 41.8 |
| 112 | 33.2 | 34.2 | 35.1 | 36.1 | 37.0 | 38.0 | 38.9 | 39.8 | 40.7 | 41.6 |
| 114 | 33.1 | 34.1 | 35.0 | 36.0 | 36.9 | 37.8 | 38.7 | 39.7 | 40.6 | 41.5 |
| 116 | 33.0 | 34.0 | 34.9 | 35.9 | 36.8 | 37.7 | 38.6 | 39.5 | 40.4 | 41.4 |
| 118 | 32.9 | 33.9 | 34.8 | 35.7 | 36.6 | 37.5 | 38.4 | 39.4 | 40.3 | 41.2 |
| 120 | 32.8 | 33.7 | 34.6 | 35.6 | 36.5 | 37.4 | 38.3 | 39.2 | 40.1 | 41.0 |

| Observed temperature in °F | Observed degrees Baume | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 47.0 | 48.0 | 49.0 | 50.0 | 51.0 | 52.0 | 53.0 | 54.0 | 55.0 | 56.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 49.8 | 50.8 | 51.9 | 53.0 | 54.1 | 55.1 | 56.2 | 57.3 | 58.4 | 59.4 |
| 32 | 49.6 | 50.6 | 51.7 | 52.8 | 53.9 | 54.9 | 56.0 | 57.1 | 58.2 | 59.2 |
| 34 | 49.4 | 50.4 | 51.5 | 52.6 | 53.7 | 54.7 | 55.8 | 56.8 | 57.9 | 58.9 |
| 36 | 49.3 | 50.3 | 51.4 | 52.4 | 53.5 | 54.5 | 55.6 | 56.6 | 57.7 | 58.7 |
| 38 | 49.1 | 50.1 | 51.2 | 52.2 | 53.3 | 54.3 | 55.4 | 56.4 | 57.5 | 58.5 |
| 40 | 48.9 | 49.9 | 51.0 | 52.0 | 53.0 | 54.1 | 55.2 | 56.2 | 57.2 | 58.2 |
| 42 | 48.7 | 49.7 | 50.8 | 51.8 | 52.8 | 53.8 | 54.9 | 56.0 | 57.0 | 58.0 |
| 44 | 48.5 | 49.5 | 50.6 | 51.6 | 52.6 | 53.6 | 54.7 | 55.7 | 56.8 | 57.8 |
| 46 | 48.3 | 49.3 | 50.4 | 51.4 | 52.4 | 53.4 | 54.5 | 55.5 | 56.5 | 57.5 |
| 48 | 48.1 | 49.1 | 50.2 | 51.2 | 52.2 | 53.2 | 54.2 | 55.2 | 56.3 | 57.3 |
| 50 | 47.9 | 48.9 | 50.0 | 51.0 | 52.0 | 53.0 | 54.0 | 55.0 | 56.1 | 57.1 |
| 52 | 47.7 | 48.7 | 49.8 | 50.8 | 51.8 | 52.8 | 53.8 | 54.8 | 55.9 | 56.9 |
| 54 | 47.6 | 48.6 | 49.6 | 50.6 | 51.6 | 52.6 | 53.6 | 54.6 | 55.6 | 56.6 |
| 56 | 47.4 | 48.4 | 49.4 | 50.4 | 51.4 | 52.4 | 53.4 | 54.4 | 55.4 | 56.4 |
| 58 | 47.2 | 48.2 | 49.2 | 50.2 | 51.2 | 52.2 | 53.2 | 54.2 | 55.2 | 56.2 |
| 60 | 47.0 | 48.0 | 49.0 | 50.0 | 51.0 | 52.0 | 53.0 | 54.0 | 55.0 | 56.0 |
| 62 | 46.9 | 47.9 | 48.8 | 49.8 | 50.8 | 51.8 | 52.8 | 53.8 | 54.8 | 55.8 |
| 64 | 46.7 | 47.7 | 48.6 | 49.6 | 50.6 | 51.6 | 52.6 | 53.6 | 54.6 | 55.6 |
| 66 | 46.5 | 47.5 | 48.4 | 49.4 | 50.4 | 51.4 | 52.4 | 53.4 | 54.4 | 55.4 |
| 68 | 46.3 | 47.3 | 48.3 | 49.3 | 50.3 | 51.3 | 52.2 | 53.2 | 54.2 | 55.2 |
| 70 | 46.1 | 47.1 | 48.1 | 49.1 | 50.1 | 51.1 | 52.0 | 53.0 | 54.0 | 55.0 |
| 72 | 46.0 | 47.0 | 47.9 | 48.9 | 49.9 | 50.9 | 51.8 | 52.8 | 53.8 | 54.8 |
| 74 | 45.8 | 46.8 | 47.7 | 48.7 | 49.7 | 50.7 | 51.6 | 52.6 | 53.5 | 54.5 |
| 76 | 45.6 | 46.6 | 47.5 | 48.5 | 49.5 | 50.5 | 51.4 | 52.4 | 53.3 | 54.3 |
| 78 | 45.4 | 46.4 | 47.3 | 48.3 | 49.3 | 50.3 | 51.2 | 52.2 | 53.1 | 54.1 |
| 80 | 45.2 | 46.2 | 47.2 | 48.2 | 49.1 | 50.1 | 51.0 | 52.0 | 52.9 | 53.9 |
| 82 | 45.1 | 46.1 | 47.0 | 48.0 | 48.9 | 49.9 | 50.8 | 51.8 | 52.7 | 53.7 |
| 84 | 44.9 | 45.9 | 46.8 | 47.8 | 48.7 | 49.7 | 50.6 | 51.6 | 52.5 | 53.5 |
| 86 | 44.7 | 45.7 | 46.6 | 47.6 | 48.5 | 49.5 | 50.4 | 51.4 | 52.3 | 53.3 |
| 88 | 44.5 | 45.5 | 46.4 | 47.4 | 48.3 | 49.3 | 50.2 | 51.2 | 52.1 | 53.1 |
| 90 | 44.4 | 45.4 | 46.3 | 47.3 | 48.2 | 49.2 | 50.1 | 51.0 | 51.9 | 52.9 |
| 92 | 44.2 | 45.2 | 46.1 | 47.1 | 48.0 | 49.0 | 49.9 | 50.9 | 51.8 | 52.7 |
| 94 | 44.1 | 45.1 | 46.0 | 46.9 | 47.8 | 48.8 | 49.7 | 50.7 | 51.6 | 52.5 |
| 96 | 43.9 | 44.9 | 45.8 | 46.7 | 47.6 | 48.6 | 49.5 | 50.5 | 51.4 | 52.3 |
| 98 | 43.7 | 44.7 | 45.6 | 46.6 | 47.5 | 48.4 | 49.3 | 50.3 | 51.2 | 52.1 |
| 100 | 43.5 | 44.5 | 45.4 | 46.4 | 47.3 | 48.3 | 49.2 | 50.1 | 51.0 | 51.9 |
| 102 | 43.4 | 44.3 | 45.2 | 46.2 | 47.1 | 48.1 | 49.0 | 49.9 | 50.8 | 51.7 |
| 104 | 43.2 | 44.1 | 45.0 | 46.0 | 46.9 | 47.9 | 48.8 | 49.7 | 50.6 | 51.5 |
| 106 | 43.1 | 44.0 | 44.9 | 45.8 | 46.7 | 47.7 | 48.6 | 49.5 | 50.4 | 51.3 |
| 108 | 42.9 | 43.9 | 44.8 | 45.7 | 46.6 | 47.5 | 48.4 | 49.4 | 50.3 | 51.2 |
| 110 | 42.7 | 43.7 | 44.6 | 45.6 | 46.5 | 47.4 | 48.3 | 49.2 | 50.1 | 51.0 |
| 112 | 42.5 | 43.5 | 44.4 | 45.4 | 46.3 | 47.2 | 48.1 | 49.0 | 49.9 | 50.8 |
| 114 | 42.4 | 43.4 | 44.3 | 45.3 | 46.2 | 47.1 | 48.0 | 48.8 | 49.7 | 50.6 |
| 116 | 42.3 | 43.3 | 44.2 | 45.1 | 46.0 | 46.9 | 47.8 | 48.6 | 49.5 | 50.4 |
| 118 | 42.1 | 43.1 | 44.0 | 44.9 | 45.8 | 46.7 | 47.6 | 48.4 | 49.3 | 50.2 |
| 120 | 41.9 | 42.9 | 43.8 | 44.7 | 45.6 | 46.5 | 47.4 | 48.2 | 49.1 | 50.0 |

| Observed temperature in ° F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 57.0 | 58.0 | 59.0 | 60.0 | 61.0 | 62.0 | 63.0 | 64.0 | 65.0 | 66.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 60.5 | 61.6 | 62.7 | 63.7 | 64.8 | 65.8 | 66.9 | 67.9 | 69.0 | 70.0 |
| 32 | 60.3 | 61.3 | 62.4 | 63.4 | 64.5 | 65.5 | 66.6 | 67.7 | 68.8 | 69.8 |
| 34 | 60.0 | 61.0 | 62.1 | 63.1 | 64.2 | 65.2 | 66.3 | 67.4 | 68.5 | 69.5 |
| 36 | 59.8 | 60.8 | 61.9 | 62.9 | 64.0 | 65.0 | 66.1 | 67.1 | 68.2 | 69.2 |
| 38 | 59.5 | 60.5 | 61.6 | 62.6 | 63.7 | 64.7 | 65.8 | 66.8 | 67.9 | 68.9 |
| 40 | 59.3 | 60.3 | 61.4 | 62.4 | 63.5 | 64.5 | 65.5 | 66.5 | 67.6 | 68.6 |
| 42 | 59.1 | 60.1 | 61.2 | 62.2 | 63.3 | 64.3 | 65.3 | 66.3 | 67.4 | 68.4 |
| 44 | 58.9 | 59.9 | 61.0 | 62.0 | 63.0 | 64.0 | 65.0 | 66.0 | 67.1 | 68.1 |
| 46 | 58.6 | 59.6 | 60.7 | 61.7 | 62.7 | 63.7 | 64.8 | 65.8 | 66.8 | 67.8 |
| 48 | 58.4 | 59.4 | 60.4 | 61.4 | 62.5 | 63.5 | 64.5 | 65.5 | 66.5 | 67.5 |
| 50 | 58.1 | 59.1 | 60.2 | 61.2 | 62.2 | 63.2 | 64.2 | 65.2 | 66.2 | 67.2 |
| 52 | 57.9 | 58.9 | 60.0 | 61.0 | 62.0 | 63.0 | 64.0 | 65.0 | 66.0 | 67.0 |
| 54 | 57.7 | 58.7 | 59.8 | 60.8 | 61.8 | 62.8 | 63.8 | 64.8 | 65.8 | 66.8 |
| 56 | 57.5 | 58.5 | 59.5 | 60.5 | 61.5 | 62.5 | 63.6 | 64.6 | 65.6 | 66.6 |
| 58 | 57.3 | 58.3 | 59.3 | 60.3 | 61.3 | 62.3 | 63.3 | 64.3 | 65.3 | 66.3 |
| 60 | 57.0 | 58.0 | 59.0 | 60.0 | 61.0 | 62.0 | 63.0 | 64.0 | 65.0 | 66.0 |
| 62 | 56.8 | 57.8 | 58.8 | 59.8 | 60.8 | 61.8 | 62.7 | 63.7 | 64.7 | 65.7 |
| 64 | 56.6 | 57.6 | 58.6 | 59.6 | 60.5 | 61.5 | 62.5 | 63.5 | 64.5 | 65.5 |
| 66 | 56.4 | 57.4 | 58.3 | 59.3 | 60.3 | 61.3 | 62.3 | 63.3 | 64.2 | 65.2 |
| 68 | 56.1 | 57.1 | 58.1 | 59.1 | 60.1 | 61.1 | 62.1 | 63.1 | 64.0 | 65.0 |
| 70 | 55.9 | 56.9 | 57.9 | 58.9 | 59.8 | 60.8 | 61.8 | 62.8 | 63.8 | 64.8 |
| 72 | 55.7 | 56.7 | 57.7 | 58.7 | 59.6 | 60.6 | 61.6 | 62.6 | 63.5 | 64.5 |
| 74 | 55.5 | 56.5 | 57.4 | 58.4 | 59.3 | 60.3 | 61.3 | 62.3 | 63.2 | 64.2 |
| 76 | 55.3 | 56.3 | 57.2 | 58.2 | 59.1 | 60.1 | 61.0 | 62.0 | 63.0 | 64.0 |
| 78 | 55.0 | 56.0 | 57.0 | 58.0 | 58.9 | 59.9 | 60.8 | 61.8 | 62.8 | 63.8 |
| 80 | 54.8 | 55.8 | 56.8 | 57.8 | 58.7 | 59.7 | 60.6 | 61.6 | 62.6 | 63.6 |
| 82 | 54.6 | 55.6 | 56.5 | 57.5 | 58.4 | 59.4 | 60.4 | 61.4 | 62.3 | 63.3 |
| 84 | 54.4 | 55.4 | 56.3 | 57.3 | 58.2 | 59.2 | 60.1 | 61.1 | 62.0 | 63.0 |
| 86 | 54.2 | 55.2 | 56.1 | 57.1 | 58.0 | 59.0 | 59.9 | 60.9 | 61.8 | 62.8 |
| 88 | 54.0 | 55.0 | 55.9 | 56.9 | 57.8 | 58.8 | 59.7 | 60.6 | 61.5 | 62.5 |
| 90 | 53.8 | 54.8 | 55.7 | 56.7 | 57.6 | 58.6 | 59.5 | 60.4 | 61.3 | 62.3 |
| 92 | 53.6 | 54.6 | 55.5 | 56.5 | 57.4 | 58.4 | 59.3 | 60.2 | 61.1 | 62.1 |
| 94 | 53.4 | 54.3 | 55.2 | 56.2 | 57.1 | 58.1 | 59.0 | 59.9 | 60.8 | 61.8 |
| 96 | 53.2 | 54.1 | 55.0 | 56.0 | 56.9 | 57.9 | 58.8 | 59.7 | 60.6 | 61.6 |
| 98 | 53.0 | 53.9 | 54.8 | 55.8 | 56.7 | 57.6 | 58.5 | 59.5 | 60.4 | 61.3 |
| 100 | 52.8 | 53.7 | 54.6 | 55.6 | 56.5 | 57.4 | 58.3 | 59.3 | 60.2 | 61.1 |
| 102 | 52.6 | 53.5 | 54.4 | 55.4 | 56.3 | 57.2 | 58.1 | 59.0 | 59.9 | 60.9 |
| 104 | 52.4 | 53.3 | 54.2 | 55.2 | 56.1 | 57.0 | 57.9 | 58.8 | 59.7 | 60.7 |
| 106 | 52.2 | 53.1 | 54.0 | 55.0 | 55.9 | 56.8 | 57.7 | 58.6 | 59.5 | 60.4 |
| 108 | 52.1 | 53.0 | 53.9 | 54.8 | 55.7 | 56.6 | 57.5 | 58.4 | 59.3 | 60.2 |
| 110 | 51.9 | 52.8 | 53.7 | 54.6 | 55.5 | 56.4 | 57.3 | 58.2 | 59.1 | 60.0 |
| 112 | 51.7 | 52.6 | 53.5 | 54.4 | 55.2 | 56.2 | 57.1 | 58.0 | 58.9 | 59.8 |
| 114 | 51.5 | 52.4 | 53.3 | 54.2 | 55.1 | 56.0 | 56.9 | 57.8 | 58.7 | 59.6 |
| 116 | 51.3 | 52.2 | 53.1 | 54.0 | 54.9 | 55.8 | 56.7 | 57.6 | 58.4 | 59.3 |
| 118 | 51.1 | 52.0 | 52.9 | 53.8 | 54.7 | 55.6 | 56.5 | 57.4 | 58.2 | 59.1 |
| 120 | 50.9 | 51.8 | 52.7 | 53.6 | 54.5 | 55.4 | 56.3 | 57.2 | 58.0 | 58.9 |

| Observed temperature in °F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 67.0 | 68.0 | 69.0 | 70.0 | 71.0 | 72.0 | 73.0 | 74.0 | 75.0 | 76.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 71.1 | 72.1 | 73.2 | 74.3 | 75.4 | 76.4 | 77.5 | 78.5 | 79.6 | 80.7 |
| 32 | 70.9 | 71.9 | 73.0 | 74.0 | 75.1 | 76.1 | 77.2 | 78.2 | 79.3 | 80.4 |
| 34 | 70.6 | 71.6 | 72.7 | 73.7 | 74.8 | 75.8 | 76.9 | 77.9 | 79.0 | 80.1 |
| 36 | 70.3 | 71.3 | 72.4 | 73.4 | 74.5 | 75.5 | 76.6 | 77.6 | 78.7 | 79.7 |
| 38 | 70.0 | 71.0 | 72.1 | 73.1 | 74.2 | 75.2 | 76.3 | 77.3 | 78.4 | 79.4 |
| 40 | 69.7 | 70.7 | 71.8 | 72.8 | 73.9 | 74.9 | 76.0 | 77.0 | 78.1 | 79.1 |
| 42 | 69.4 | 70.4 | 71.5 | 72.5 | 73.6 | 74.6 | 75.7 | 76.7 | 77.8 | 78.8 |
| 44 | 69.1 | 70.1 | 71.2 | 72.2 | 73.3 | 74.3 | 75.4 | 76.4 | 77.5 | 78.5 |
| 46 | 68.8 | 69.8 | 70.9 | 71.9 | 73.0 | 74.0 | 75.1 | 76.1 | 77.1 | 78.1 |
| 48 | 68.6 | 69.6 | 70.6 | 71.6 | 72.7 | 73.7 | 74.8 | 75.8 | 76.8 | 77.8 |
| 50 | 68.3 | 69.3 | 70.4 | 71.4 | 72.5 | 73.5 | 74.5 | 75.5 | 76.5 | 77.5 |
| 52 | 68.0 | 69.0 | 70.1 | 71.1 | 72.2 | 73.2 | 74.2 | 75.2 | 76.2 | 77.2 |
| 54 | 67.8 | 68.8 | 69.9 | 70.9 | 71.9 | 72.9 | 73.9 | 74.9 | 75.9 | 76.9 |
| 56 | 67.6 | 68.6 | 69.6 | 70.6 | 71.6 | 72.6 | 73.6 | 74.6 | 75.6 | 76.6 |
| 58 | 67.3 | 68.3 | 69.3 | 70.3 | 71.3 | 72.3 | 73.3 | 74.3 | 75.3 | 76.3 |
| 60 | 67.0 | 68.0 | 69.0 | 70.0 | 71.0 | 72.0 | 73.0 | 74.0 | 75.0 | 76.0 |
| 62 | 66.7 | 67.7 | 68.7 | 69.7 | 70.7 | 71.7 | 72.7 | 73.7 | 74.7 | 75.7 |
| 64 | 66.4 | 67.4 | 68.4 | 69.4 | 70.4 | 71.4 | 72.4 | 73.4 | 74.4 | 75.4 |
| 66 | 66.2 | 67.2 | 68.2 | 69.2 | 70.1 | 71.1 | 72.1 | 73.1 | 74.1 | 75.1 |
| 68 | 66.0 | 67.0 | 67.9 | 68.9 | 69.8 | 70.8 | 71.8 | 72.8 | 73.8 | 74.8 |
| 70 | 65.7 | 66.7 | 67.6 | 68.6 | 69.5 | 70.5 | 71.5 | 72.5 | 73.5 | 74.5 |
| 72 | 65.4 | 66.4 | 67.4 | 68.4 | 69.3 | 70.3 | 71.2 | 72.2 | 73.2 | 74.2 |
| 74 | 65.2 | 66.2 | 67.2 | 68.2 | 69.1 | 70.1 | 71.0 | 72.0 | 72.9 | 73.9 |
| 76 | 64.9 | 65.9 | 66.9 | 67.9 | 68.8 | 69.8 | 70.8 | 71.8 | 72.7 | 73.7 |
| 78 | 64.7 | 65.6 | 66.6 | 67.6 | 68.5 | 69.5 | 70.5 | 71.5 | 72.4 | 73.4 |
| 80 | 64.5 | 65.4 | 66.4 | 67.4 | 68.3 | 69.3 | 70.2 | 71.2 | 72.1 | 73.1 |
| 82 | 64.2 | 65.2 | 66.1 | 67.1 | 68.0 | 69.0 | 69.9 | 70.9 | 71.8 | 72.8 |
| 84 | 63.9 | 64.9 | 65.8 | 66.8 | 67.7 | 68.7 | 69.6 | 70.6 | 71.5 | 72.5 |
| 86 | 63.7 | 64.7 | 65.6 | 66.6 | 67.5 | 68.4 | 69.3 | 70.3 | 71.3 | 72.3 |
| 88 | 63.4 | 64.4 | 65.3 | 66.3 | 67.2 | 68.2 | 69.1 | 70.1 | 71.0 | 72.0 |
| 90 | 63.2 | 64.2 | 65.1 | 66.1 | 67.0 | 68.0 | 68.9 | 69.9 | 70.8 | 71.7 |
| 92 | 63.0 | 64.0 | 64.9 | 65.8 | 66.7 | 67.7 | 68.6 | 69.6 | 70.5 | 71.4 |
| 94 | 62.7 | 63.7 | 64.6 | 65.6 | 66.5 | 67.4 | 68.3 | 69.3 | 70.2 | 71.1 |
| 96 | 62.5 | 63.5 | 64.4 | 65.4 | 66.3 | 67.2 | 68.1 | 69.0 | 69.9 | 70.8 |
| 98 | 62.2 | 63.2 | 64.1 | 65.1 | 66.0 | 66.9 | 67.8 | 68.8 | 69.7 | 70.6 |
| 100 | 62.0 | 63.0 | 63.9 | 64.9 | 65.8 | 66.7 | 67.6 | 68.5 | 69.4 | 70.4 |
| 102 | 61.8 | 62.8 | 63.7 | 64.6 | 65.5 | 66.4 | 67.3 | 68.2 | 69.1 | 70.1 |
| 104 | 61.6 | 62.5 | 63.4 | 64.3 | 65.2 | 66.1 | 67.0 | 67.9 | 68.8 | 69.8 |
| 106 | 61.3 | 62.3 | 63.2 | 64.1 | 65.0 | 65.9 | 66.8 | 67.7 | 68.6 | 69.5 |
| 108 | 61.1 | 62.0 | 62.9 | 63.8 | 64.8 | 65.7 | 66.6 | 67.5 | 68.4 | 69.3 |
| 110 | 60.9 | 61.8 | 62.7 | 63.6 | 64.5 | 65.4 | 66.3 | 67.2 | 68.1 | 69.0 |
| 112 | 60.7 | 61.6 | 62.5 | 63.3 | 64.2 | 65.2 | 66.1 | 67.0 | 67.8 | 68.7 |
| 114 | 60.5 | 61.4 | 62.3 | 63.1 | 64.0 | 64.9 | 65.8 | 66.7 | 67.6 | 68.5 |
| 116 | 60.2 | 61.1 | 62.0 | 62.9 | 63.8 | 64.7 | 65.6 | 66.5 | 67.4 | 68.3 |
| 118 | 60.0 | 60.9 | 61.8 | 62.7 | 63.6 | 64.5 | 65.4 | 66.3 | 67.1 | 68.0 |
| 120 | 59.8 | 60.7 | 61.6 | 62.5 | 63.3 | 64.2 | 65.1 | 66.0 | 66.8 | 67.7 |

| Observed temperature in ° F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 77.0 | 78.0 | 79.0 | 80.0 | 81.0 | 82.0 | 83.0 | 84.0 | 85.0 | 86.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 81.8 | 82.9 | 84.0 | 85.0 | 86.1 | 87.1 | 88.2 | 89.3 | 90.4 | 91.5 |
| 32 | 81.5 | 82.6 | 83.7 | 84.7 | 85.8 | 86.8 | 87.9 | 89.0 | 90.1 | 91.1 |
| 34 | 81.2 | 82.2 | 83.3 | 84.3 | 85.4 | 86.4 | 87.5 | 88.6 | 89.7 | 90.7 |
| 36 | 80.8 | 81.9 | 83.0 | 84.0 | 85.1 | 86.1 | 87.2 | 88.2 | 89.3 | 90.3 |
| 38 | 80.5 | 81.5 | 82.6 | 83.6 | 84.7 | 85.7 | 86.8 | 87.8 | 88.9 | 89.9 |
| 40 | 80.1 | 81.1 | 82.2 | 83.2 | 84.3 | 85.3 | 86.4 | 87.4 | 88.5 | 89.5 |
| 42 | 79.8 | 80.8 | 81.9 | 82.9 | 84.0 | 85.0 | 86.1 | 87.1 | 88.2 | 89.2 |
| 44 | 79.5 | 80.5 | 81.6 | 82.6 | 83.7 | 84.7 | 85.8 | 86.8 | 87.8 | 88.8 |
| 46 | 79.2 | 80.2 | 81.3 | 82.3 | 83.4 | 84.4 | 85.4 | 86.5 | 87.5 | 88.5 |
| 48 | 78.9 | 79.9 | 81.0 | 82.0 | 83.0 | 84.0 | 85.1 | 86.1 | 87.1 | 88.1 |
| 50 | 78.6 | 79.6 | 80.6 | 81.6 | 82.6 | 83.6 | 84.7 | 85.7 | 86.7 | 87.7 |
| 52 | 78.2 | 79.2 | 80.3 | 81.3 | 82.3 | 83.3 | 84.3 | 85.3 | 86.3 | 87.3 |
| 54 | 77.9 | 78.9 | 79.9 | 81.0 | 82.0 | 83.0 | 84.0 | 85.0 | 86.0 | 87.0 |
| 56 | 77.6 | 78.6 | 79.6 | 80.6 | 81.6 | 82.6 | 83.7 | 84.7 | 85.7 | 86.7 |
| 58 | 77.3 | 78.3 | 79.3 | 80.3 | 81.3 | 82.3 | 83.3 | 84.3 | 85.3 | 86.3 |
| 60 | 77.0 | 78.0 | 79.0 | 80.0 | 81.0 | 82.0 | 83.0 | 84.0 | 85.0 | 86.0 |
| 62 | 76.7 | 77.7 | 78.7 | 79.7 | 80.7 | 81.7 | 82.7 | 83.7 | 84.7 | 85.7 |
| 64 | 76.4 | 77.4 | 78.4 | 79.4 | 80.4 | 81.4 | 82.3 | 83.4 | 84.3 | 85.3 |
| 66 | 76.1 | 77.1 | 78.1 | 79.1 | 80.0 | 81.0 | 82.0 | 83.0 | 84.0 | 85.0 |
| 68 | 75.8 | 76.8 | 77.7 | 78.7 | 79.7 | 80.7 | 81.7 | 82.7 | 83.7 | 84.7 |
| 70 | 75.5 | 76.5 | 77.4 | 78.4 | 79.4 | 80.4 | 81.4 | 82.4 | 83.3 | 84.3 |
| 72 | 75.2 | 76.2 | 77.1 | 78.1 | 79.1 | 80.1 | 81.1 | 82.1 | 83.0 | 84.0 |
| 74 | 74.9 | 75.9 | 76.8 | 77.8 | 78.8 | 79.8 | 80.7 | 81.7 | 82.7 | 83.7 |
| 76 | 74.6 | 75.6 | 76.5 | 77.5 | 78.4 | 79.4 | 80.4 | 81.4 | 82.4 | 83.4 |
| 78 | 74.3 | 75.3 | 76.2 | 77.2 | 78.1 | 79.1 | 80.1 | 81.1 | 82.0 | 83.0 |
| 80 | 74.0 | 75.0 | 75.9 | 76.9 | 77.8 | 78.8 | 79.8 | 80.8 | 81.7 | 82.7 |
| 82 | 73.7 | 74.7 | 75.6 | 76.6 | 77.5 | 78.5 | 79.4 | 80.4 | 81.3 | 82.3 |
| 84 | 73.4 | 74.5 | 75.3 | 76.3 | 77.2 | 78.2 | 79.1 | 80.1 | 81.0 | 82.0 |
| 86 | 73.2 | 74.1 | 75.0 | 76.0 | 76.9 | 77.9 | 78.8 | 79.8 | 80.7 | 81.7 |
| 88 | 72.9 | 73.9 | 74.8 | 75.8 | 76.7 | 77.6 | 78.5 | 79.5 | 80.4 | 81.4 |
| 90 | 72.6 | 73.6 | 74.5 | 75.5 | 76.4 | 77.3 | 78.2 | 79.2 | 80.1 | 81.1 |
| 92 | 72.3 | 73.3 | 74.2 | 75.2 | 76.1 | 77.0 | 77.9 | 78.9 | 79.8 | 80.8 |
| 94 | 72.0 | 73.0 | 73.9 | 74.9 | 75.8 | 76.7 | 77.6 | 78.6 | 79.5 | 80.5 |
| 96 | 71.7 | 72.7 | 73.6 | 74.6 | 75.5 | 76.4 | 77.3 | 78.3 | 79.2 | 80.2 |
| 98 | 71.5 | 72.4 | 73.3 | 74.3 | 75.2 | 76.1 | 77.0 | 78.0 | 78.9 | 79.8 |
| 100 | 71.2 | 72.1 | 73.0 | 74.0 | 74.9 | 75.8 | 76.7 | 77.6 | 78.5 | 79.5 |
| 102 | 71.0 | 71.9 | 72.8 | 73.7 | 74.6 | 75.5 | 76.4 | 77.3 | 78.2 | 79.2 |
| 104 | 70.7 | 71.6 | 72.5 | 73.4 | 74.3 | 75.2 | 76.1 | 77.0 | 77.9 | 78.8 |
| 106 | 70.4 | 71.3 | 72.2 | 73.1 | 74.0 | 74.9 | 75.8 | 76.7 | 77.6 | 78.5 |
| 108 | 70.1 | 71.0 | 71.9 | 72.8 | 73.7 | 74.6 | 75.5 | 76.4 | 77.3 | 78.2 |
| 110 | 69.8 | 70.7 | 71.6 | 72.5 | 73.4 | 74.3 | 75.2 | 76.1 | 77.0 | 77.9 |
| 112 | 69.6 | 70.5 | 71.4 | 72.3 | 73.2 | 74.1 | 74.9 | 75.8 | 76.7 | 77.6 |
| 114 | 69.4 | 70.3 | 71.2 | 72.1 | 72.9 | 73.8 | 74.6 | 75.5 | 76.4 | 77.3 |
| 116 | 69.1 | 70.0 | 70.9 | 71.8 | 72.6 | 73.5 | 74.3 | 75.2 | 76.1 | 77.0 |
| 118 | 68.8 | 69.7 | 70.6 | 71.5 | 72.3 | 73.2 | 74.0 | 74.9 | 75.8 | 76.7 |
| 120 | 68.5 | 69.4 | 70.3 | 71.2 | 72.0 | 72.9 | 73.7 | 74.6 | 75.5 | 76.4 |

| Observed temperature in °F | Observed degrees Baumé | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 87.0 | 88.0 | 89.0 | 90.0 | 91.0 | 92.0 | 93.0 | 94.0 | 95.0 | 96.0 |
| | Corresponding degrees Baumé at 60° F | | | | | | | | | |
| 30 | 92.6 | 93.6 | 94.7 | 95.7 | | | | | | |
| 32 | 92.2 | 93.2 | 94.3 | 95.3 | | | | | | |
| 34 | 91.8 | 92.9 | 93.9 | 94.9 | 95.9 | | | | | |
| 36 | 91.4 | 92.5 | 93.6 | 94.6 | 95.6 | | | | | |
| 38 | 91.0 | 92.1 | 93.2 | 94.2 | 95.2 | | | | | |
| 40 | 90.6 | 91.7 | 92.8 | 93.8 | 94.9 | 95.9 | | | | |
| 42 | 90.3 | 91.3 | 92.4 | 93.4 | 94.5 | 95.5 | | | | |
| 44 | 89.9 | 90.9 | 92.0 | 93.0 | 94.1 | 95.1 | 96.1 | | | |
| 46 | 89.6 | 90.6 | 91.7 | 92.7 | 93.7 | 94.7 | 95.7 | | | |
| 48 | 89.2 | 90.2 | 91.3 | 92.3 | 93.3 | 94.3 | 95.3 | | | |
| 50 | 88.8 | 89.8 | 90.9 | 91.9 | 92.9 | 93.9 | 94.9 | 95.9 | | |
| 52 | 88.4 | 89.4 | 90.5 | 91.5 | 92.5 | 93.5 | 94.5 | 95.5 | | |
| 54 | 88.0 | 89.0 | 90.1 | 91.1 | 92.1 | 93.1 | 94.1 | 95.1 | | |
| 56 | 87.7 | 88.7 | 89.7 | 90.7 | 91.7 | 92.7 | 93.7 | 94.7 | 95.7 | |
| 58 | 87.3 | 88.3 | 89.4 | 90.4 | 91.4 | 92.4 | 93.4 | 94.4 | 95.4 | |
| 60 | 87.0 | 88.0 | 89.0 | 90.0 | 91.0 | 92.0 | 93.0 | 94.0 | 95.0 | 96.0 |
| 62 | 86.7 | 87.7 | 88.6 | 89.6 | 90.6 | 91.6 | 92.6 | 93.6 | 94.6 | 95.6 |
| 64 | 86.3 | 87.3 | 88.3 | 89.3 | 90.3 | 91.3 | 92.2 | 93.2 | 94.2 | 95.2 |
| 66 | 86.0 | 87.0 | 88.0 | 89.0 | 89.9 | 90.9 | 91.8 | 92.8 | 93.8 | 94.8 |
| 68 | 85.6 | 86.6 | 87.6 | 88.6 | 89.5 | 90.5 | 91.4 | 92.4 | 93.4 | 94.4 |
| 70 | 85.3 | 86.3 | 87.3 | 88.3 | 89.2 | 90.1 | 91.0 | 92.0 | 93.0 | 94.0 |
| 72 | 85.0 | 86.0 | 86.9 | 87.9 | 88.8 | 89.8 | 90.7 | 91.7 | 92.7 | 93.7 |
| 74 | 84.6 | 85.6 | 86.5 | 87.5 | 88.4 | 89.4 | 90.3 | 91.3 | 92.3 | 93.3 |
| 76 | 84.3 | 85.3 | 86.2 | 87.2 | 88.1 | 89.1 | 90.0 | 91.0 | 92.0 | 93.0 |
| 78 | 84.0 | 85.0 | 85.9 | 86.9 | 87.8 | 88.7 | 89.6 | 90.6 | 91.6 | 92.6 |
| 80 | 83.6 | 84.6 | 85.5 | 86.5 | 87.4 | 88.4 | 89.3 | 90.2 | 91.2 | 92.2 |
| 82 | 83.2 | 84.2 | 85.1 | 86.1 | 87.0 | 88.0 | 88.9 | 89.8 | 90.8 | 91.8 |
| 84 | 82.9 | 83.8 | 84.7 | 85.7 | 86.6 | 87.6 | 88.5 | 89.4 | 90.4 | 91.4 |
| 86 | 82.6 | 83.5 | 84.4 | 85.4 | 86.3 | 87.3 | 88.2 | 89.1 | 90.0 | 91.0 |
| 88 | 82.3 | 83.2 | 84.1 | 85.1 | 86.0 | 87.0 | 87.9 | 88.8 | 89.7 | 90.7 |
| 90 | 82.0 | 82.9 | 83.8 | 84.8 | 85.7 | 86.6 | 87.5 | 88.4 | 89.3 | 90.3 |
| 92 | 81.7 | 82.6 | 83.5 | 84.4 | 85.3 | 86.2 | 87.1 | 88.1 | 89.0 | 90.0 |
| 94 | 81.3 | 82.2 | 83.1 | 84.1 | 85.0 | 85.9 | 86.8 | 87.7 | 88.6 | 89.6 |
| 96 | 81.0 | 81.9 | 82.8 | 83.7 | 84.6 | 85.6 | 86.5 | 87.4 | 88.3 | 89.3 |
| 98 | 80.7 | 81.6 | 82.5 | 83.4 | 84.3 | 85.2 | 86.1 | 87.0 | 88.0 | 89.0 |
| 100 | 80.4 | 81.3 | 82.2 | 83.1 | 84.0 | 84.9 | 85.8 | 86.7 | 87.6 | 88.6 |
| 102 | 80.1 | 81.0 | 81.9 | 82.8 | 83.7 | 84.6 | 85.5 | 86.4 | 87.3 | 88.3 |
| 104 | 79.7 | 80.6 | 81.5 | 82.5 | 83.4 | 84.3 | 85.2 | 86.1 | 87.0 | 87.9 |
| 106 | 79.4 | 80.3 | 81.2 | 82.1 | 83.0 | 83.9 | 84.8 | 85.7 | 86.6 | 87.6 |
| 108 | 79.1 | 80.0 | 80.9 | 81.8 | 82.7 | 83.6 | 84.5 | 85.4 | 86.3 | 87.2 |
| 110 | 78.8 | 79.7 | 80.6 | 81.5 | 82.4 | 83.3 | 84.2 | 85.1 | 86.0 | 86.9 |
| 112 | 78.5 | 79.4 | 80.3 | 81.2 | 82.1 | 83.0 | 83.8 | 84.7 | 85.6 | 86.6 |
| 114 | 78.2 | 79.1 | 80.0 | 80.9 | 81.7 | 82.6 | 83.5 | 84.4 | 85.3 | 86.2 |
| 116 | 77.9 | 78.8 | 79.7 | 80.6 | 81.4 | 82.3 | 83.2 | 84.1 | 85.0 | 85.9 |
| 118 | 77.5 | 78.4 | 79.3 | 80.2 | 81.1 | 82.0 | 82.8 | 83.7 | 84.6 | 85.6 |
| 120 | 77.2 | 78.1 | 79.0 | 79.9 | 80.8 | 81.7 | 82.5 | 83.4 | 84.3 | 85.2 |

# Reduction of Specific Gravity Readings to 60°F

(This table shows the specific gravities at 60°/60°F of oils having, at the designated temperatures, the observed specific gravities indicated. For example, if the observed specific gravity is 0.610 at 80°F, the true specific gravity at 60°/60°F will be 0.621. The headings "Observed specific gravity" and "Observed temperature" signify the true indication of the hydrometer and the true temperature of the oil; that is, the observed readings corrected, if necessary, for instrumental errors.)

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.610 | 0.611 | 0.612 | 0.613 | 0.614 | 0.615 | 0.616 | 0.617 | 0.618 | 0.619 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 62 | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | 0.6200 |
| 64 | ....... | ....... | ....... | ....... | ....... | ....... | ....... | ....... | 0.6200 | .6210 |
| 66 | ....... | ....... | ....... | ....... | ....... | ....... | ....... | 0.6200 | .6210 | .6220 |
| 68 | ....... | ....... | ....... | ....... | ....... | 0.6200 | .6205 | .6215 | .6225 | .6235 |
| 70 | ....... | ....... | ....... | ....... | 0.6200 | .6210 | .6215 | .6225 | .6235 | .6245 |
| 72 | ....... | ....... | ....... | 0.6200 | .6210 | .6220 | .6225 | .6235 | .6245 | .6255 |
| 74 | ....... | ....... | 0.6200 | .6210 | .6220 | .6230 | .6235 | .6245 | .6255 | .6265 |
| 76 | ....... | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6245 | .6255 | .6265 | .6275 |
| 78 | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6255 | .6265 | .6275 | .6285 |
| 80 | .621 | .622 | .623 | .624 | .625 | .626 | .626 | .627 | .628 | .629 |
| 82 | .622 | .623 | .624 | .625 | .626 | .627 | .628 | .629 | .630 | .631 |
| 84 | .623 | .624 | .625 | .626 | .627 | .628 | .629 | .630 | .631 | .632 |
| 86 | .624 | .625 | .626 | .627 | .628 | .629 | .630 | .631 | .632 | .633 |
| 88 | .625 | .626 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 |
| 90 | .626 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 |
| 92 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 | .636 |
| 94 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 | .636 | .637 |
| 96 | .629 | .630 | .631 | .632 | .633 | .634 | .635 | .636 | .637 | .638 |
| 98 | .630 | .631 | .632 | .633 | .634 | .635 | .636 | .637 | .638 | .639 |
| 100 | .631 | .632 | .633 | .634 | .635 | .636 | .637 | .638 | .639 | .640 |
| 102 | .632 | .633 | .634 | .635 | .636 | .637 | .638 | .639 | .640 | .641 |
| 104 | .633 | .634 | .635 | .636 | .637 | .638 | .639 | .640 | .641 | .642 |
| 106 | .634 | .635 | .636 | .637 | .638 | .639 | .640 | .641 | .642 | .643 |
| 108 | .635 | .636 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 |
| 110 | .636 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 |
| 112 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 | .646 |
| 114 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 | .646 | .647 |
| 116 | .639 | .640 | .641 | .642 | .643 | .644 | .645 | .646 | .647 | .648 |
| 118 | .640 | .641 | .642 | .643 | .644 | .645 | .646 | .647 | .648 | .649 |
| 120 | .641 | .642 | .643 | .644 | .645 | .646 | .647 | .648 | .649 | .650 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.620 | 0.621 | 0.622 | 0.623 | 0.624 | 0.625 | 0.626 | 0.627 | 0.628 | 0.629 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 44 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 0.6200 |
| 46 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 0.6200 | .6210 |
| 48 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 0.6200 | .6210 | .6220 |
| 50 | ...... | ...... | ...... | ...... | ...... | 0.6200 | 0.6205 | .6215 | .6225 | .6235 |
| 52 | ...... | ...... | ...... | ...... | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 |
| 54 | ...... | ...... | ...... | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 |
| 56 | ...... | ...... | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 |
| 58 | ...... | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 |
| 60 | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 | .6290 |
| 62 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 | .6290 | .6300 |
| 64 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 | .6290 | .6300 | .6310 |
| 66 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 | .6290 | .6300 | .6310 | .6320 |
| 68 | .6245 | .6255 | .6265 | .6275 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 |
| 70 | .6255 | .6265 | .6275 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 |
| 72 | .6265 | .6275 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 |
| 74 | .6275 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 |
| 76 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 |
| 78 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 |
| 80 | .630 | .631 | .632 | .633 | .634 | .635 | .636 | .637 | .638 | .639 |
| 82 | .632 | .633 | .634 | .635 | .636 | .637 | .637 | .638 | .639 | .640 |
| 84 | .633 | .634 | .635 | .636 | .637 | .638 | .638 | .639 | .640 | .641 |
| 86 | .634 | .635 | .636 | .637 | .638 | .639 | .639 | .640 | .641 | .642 |
| 88 | .635 | .636 | .637 | .638 | .639 | .640 | .640 | .641 | .642 | .643 |
| 90 | .636 | .637 | .638 | .639 | .640 | .641 | .641 | .642 | .643 | .644 |
| 92 | .637 | .638 | .639 | .640 | .641 | .642 | .642 | .643 | .644 | .645 |
| 94 | .638 | .639 | .640 | .641 | .642 | .643 | .643 | .644 | .645 | .646 |
| 96 | .639 | .640 | .641 | .642 | .643 | .644 | .644 | .645 | .646 | .647 |
| 98 | .640 | .641 | .642 | .643 | .644 | .645 | .645 | .646 | .647 | .648 |
| 100 | .641 | .642 | .643 | .644 | .645 | .646 | .646 | .647 | .648 | .649 |
| 102 | .642 | .643 | .644 | .645 | .646 | .647 | .647 | .648 | .649 | .650 |
| 104 | .643 | .644 | .645 | .646 | .647 | .648 | .648 | .649 | .650 | .651 |
| 106 | .644 | .645 | .646 | .647 | .648 | .649 | .649 | .650 | .651 | .652 |
| 108 | .645 | .646 | .647 | .648 | .649 | .650 | .650 | .651 | .652 | .653 |
| 110 | .646 | .647 | .648 | .649 | .650 | .651 | .651 | .652 | .653 | .654 |
| 112 | .647 | .648 | .649 | .650 | .651 | .652 | .652 | .653 | .654 | .655 |
| 114 | .648 | .649 | .650 | .651 | .652 | .653 | .653 | .654 | .655 | .656 |
| 116 | .649 | .650 | .651 | .652 | .653 | .654 | .654 | .655 | .656 | .657 |
| 118 | .650 | .651 | .652 | .653 | .654 | .655 | .655 | .656 | .657 | .658 |
| 120 | .651 | .652 | .653 | .654 | .655 | .656 | .656 | .657 | .658 | .659 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.630 | 0.631 | 0.632 | 0.633 | 0.634 | 0.635 | 0.636 | 0.637 | 0.638 | 0.639 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | ........ | ........ | ........ | ........ | ........ | ........ | 0.620 | 0.621 | 0.622 | 0.623 |
| 32 | ........ | ........ | ........ | ........ | ........ | 0.620 | .621 | .622 | .623 | .624 |
| 34 | ........ | ........ | ........ | ........ | 0.620 | .621 | .622 | .623 | .624 | .625 |
| 36 | ........ | ........ | ........ | 0.620 | .621 | .622 | .623 | .624 | .625 | .626 |
| 38 | ........ | ........ | 0.620 | .621 | .622 | .623 | .624 | .625 | .626 | .627 |
| 40 | ........ | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6255 | .6265 | .6275 | .6285 |
| 42 | 0.6200 | .6210 | .6220 | .6230 | .6240 | .6250 | .6265 | .6275 | .6285 | .6295 |
| 44 | .6210 | .6220 | .6230 | .6240 | .6250 | .6260 | .6275 | .6285 | .6295 | .6305 |
| 46 | .6220 | .6230 | .6240 | .6250 | .6260 | .6270 | .6285 | .6295 | .6305 | .6315 |
| 48 | .6230 | .6240 | .6250 | .6260 | .6270 | .6280 | .6295 | .6305 | .6315 | .6325 |
| 50 | .6245 | .6255 | .6265 | .6275 | .6285 | .6295 | .6305 | .6315 | .6325 | .6335 |
| 52 | .6260 | .6270 | .6280 | .6290 | .6300 | .6310 | .6320 | .6330 | .6340 | .6350 |
| 54 | .6270 | .6280 | .6290 | .6300 | .6310 | .6320 | .6330 | .6340 | .6350 | .6360 |
| 56 | .6280 | .6290 | .6300 | .6310 | .6320 | .6330 | .6340 | .6350 | .6360 | .6370 |
| 58 | .6290 | .6300 | .6310 | .6320 | .6330 | .6340 | .6350 | .6360 | .6370 | .6380 |
| 60 | .6300 | .6310 | .6320 | .6330 | .6340 | .6350 | .6360 | .6370 | .6380 | .6390 |
| 62 | .6310 | .6320 | .6330 | .6340 | .6350 | .6360 | .6370 | .6380 | .6390 | .6400 |
| 64 | .6320 | .6330 | .6340 | .6350 | .6360 | .6370 | .6380 | .6390 | .6400 | .6410 |
| 66 | .6330 | .6340 | .6350 | .6360 | .6370 | .6380 | .6390 | .6400 | .6410 | .6420 |
| 68 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 | .6400 | .6410 | .6420 | .6430 |
| 70 | .6355 | .6365 | .6375 | .6385 | .6395 | .6405 | .6410 | .6420 | .6430 | .6440 |
| 72 | .6365 | .6375 | .6385 | .6395 | .6405 | .6415 | .6420 | .6430 | .6440 | .6450 |
| 74 | .6375 | .6385 | .6395 | .6405 | .6415 | .6425 | .6430 | .6440 | .6450 | .6460 |
| 76 | .6385 | .6395 | .6405 | .6415 | .6425 | .6435 | .6440 | .6450 | .6460 | .6470 |
| 78 | .6395 | .6405 | .6415 | .6425 | .6435 | .6445 | .6450 | .6460 | .6470 | .6480 |
| 80 | .640 | .641 | .642 | .643 | .644 | .645 | .646 | .647 | .648 | .649 |
| 82 | .641 | .642 | .643 | .644 | .645 | .646 | .647 | .648 | .649 | .650 |
| 84 | .642 | .643 | .644 | .645 | .646 | .647 | .648 | .649 | .650 | .651 |
| 86 | .643 | .644 | .645 | .646 | .647 | .648 | .649 | .650 | .651 | .652 |
| 88 | .644 | .645 | .646 | .647 | .648 | .649 | .650 | .651 | .652 | .653 |
| 90 | .645 | .646 | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 |
| 92 | .646 | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 | .655 |
| 94 | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 | .655 | .656 |
| 96 | .648 | .649 | .650 | .651 | .652 | .653 | .654 | .655 | .656 | .657 |
| 98 | .649 | .650 | .651 | .652 | .653 | .654 | .655 | .656 | .657 | .658 |
| 100 | .650 | .651 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 |
| 102 | .651 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 |
| 104 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 |
| 106 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 |
| 108 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 |
| 110 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 |
| 112 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 |
| 114 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 |
| 116 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 |
| 118 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 |
| 120 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.640 | 0.641 | 0.642 | 0.643 | 0.644 | 0.645 | 0.646 | 0.647 | 0.648 | 0.649 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.624 | 0.625 | 0.626 | 0.627 | 0.628 | 0.629 | 0.630 | 0.631 | 0.632 | 0.633 |
| 32 | .625 | .626 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 |
| 34 | .626 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 |
| 36 | .627 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 | .636 |
| 38 | .628 | .629 | .630 | .631 | .632 | .633 | .634 | .635 | .636 | .637 |
| 40 | .6295 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 |
| 42 | .6305 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 |
| 44 | .6315 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 | .6405 |
| 46 | .6325 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 | .6405 | .6415 |
| 48 | .6335 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 | .6405 | .6415 | .6425 |
| 50 | .6345 | .6355 | .6365 | .6375 | .6385 | .6395 | .6410 | .6420 | .6430 | .6440 |
| 52 | .6360 | .6370 | .6380 | .6390 | .6400 | .6410 | .6420 | .6430 | .6440 | .6450 |
| 54 | .6370 | .6380 | .6390 | .6400 | .6410 | .6420 | .6430 | .6440 | .6450 | .6460 |
| 56 | .6380 | .6390 | .6400 | .6410 | .6420 | .6430 | .6440 | .6450 | .6460 | .6470 |
| 58 | .6390 | .6400 | .6410 | .6420 | .6430 | .6440 | .6450 | .6460 | .6470 | .6480 |
| 60 | .6400 | .6410 | .6420 | .6430 | .6440 | .6450 | .6460 | .6470 | .6480 | .6490 |
| 62 | .6410 | .6420 | .6430 | .6440 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 |
| 64 | .6420 | .6430 | .6440 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 |
| 66 | .6430 | .6440 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 |
| 68 | .6440 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 |
| 70 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 |
| 72 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 |
| 74 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 |
| 76 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 |
| 78 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 |
| 80 | .650 | .651 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 |
| 82 | .651 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 |
| 84 | .652 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 |
| 86 | .653 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 |
| 88 | .654 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 |
| 90 | .655 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 |
| 92 | .656 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 |
| 94 | .657 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 |
| 96 | .658 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 |
| 98 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 |
| 100 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 |
| 102 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 |
| 104 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 |
| 106 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 |
| 108 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 |
| 110 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 |
| 112 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 |
| 114 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 |
| 116 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 |
| 118 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 |
| 120 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.650 | 0.651 | 0.652 | 0.653 | 0.654 | 0.655 | 0.656 | 0.657 | 0.658 | 0.659 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.634 | 0.635 | 0.636 | 0.637 | 0.638 | 0.639 | 0.640 | 0.641 | 0.642 | 0.643 |
| 32 | .635 | .636 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 |
| 34 | .636 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 |
| 36 | .637 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 | .646 |
| 38 | .638 | .639 | .640 | .641 | .642 | .643 | .644 | .645 | .646 | .647 |
| 40 | .6395 | .6405 | .6415 | .6425 | .6435 | .6445 | .6455 | .6465 | .6475 | .6485 |
| 42 | .6405 | .6415 | .6425 | .6435 | .6445 | .6455 | .6465 | .6475 | .6485 | .6495 |
| 44 | .6415 | .6425 | .6435 | .6445 | .6455 | .6465 | .6475 | .6485 | .6495 | .6505 |
| 46 | .6425 | .6435 | .6445 | .6455 | .6465 | .6475 | .6485 | .6495 | .6505 | .6515 |
| 48 | .6435 | .6445 | .6455 | .6465 | .6475 | .6485 | .6495 | .6505 | .6515 | .6525 |
| 50 | .6450 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 |
| 52 | .6460 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 |
| 54 | .6470 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 |
| 56 | .6480 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 |
| 58 | .6490 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 |
| 60 | .6500 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 | .6590 |
| 62 | .6510 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 |
| 64 | .6520 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 |
| 66 | .6530 | .6540 | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 |
| 68 | .6540 | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 |
| 70 | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 |
| 72 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 |
| 74 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 |
| 76 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 |
| 78 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 |
| 80 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 |
| 82 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 |
| 84 | .662 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 |
| 86 | .663 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 |
| 88 | .664 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 |
| 90 | .665 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 |
| 92 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 |
| 94 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 |
| 96 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 |
| 98 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 |
| 100 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 |
| 102 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 |
| 104 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 | .681 |
| 106 | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 | .681 | .682 |
| 108 | .674 | .675 | .676 | .677 | .678 | .679 | .679 | .680 | .681 | .682 |
| 110 | .675 | .676 | .677 | .678 | .679 | .680 | .680 | .681 | .682 | .683 |
| 112 | .676 | .677 | .678 | .679 | .680 | .681 | .681 | .682 | .683 | .684 |
| 114 | .677 | .678 | .679 | .680 | .681 | .682 | .682 | .683 | .684 | .685 |
| 116 | .678 | .679 | .680 | .681 | .682 | .683 | .683 | .684 | .685 | .686 |
| 118 | .679 | .680 | .681 | .682 | .683 | .684 | .684 | .685 | .686 | .687 |
| 120 | .680 | .681 | .682 | .683 | .684 | .685 | .685 | .686 | .687 | .688 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.660 | 0.661 | 0.662 | 0.663 | 0.664 | 0.665 | 0.666 | 0.667 | 0.668 | 0.669 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.664 | 0.645 | 0.646 | 0.647 | 0.648 | 0.649 | 0.650 | 0.651 | 0.652 | 0.653 |
| 32.......... | .645 | .646 | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 |
| 34.......... | .646 | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 | .655 |
| 36.......... | .647 | .648 | .649 | .650 | .651 | .652 | .653 | .654 | .655 | .656 |
| 38.......... | .648 | .649 | .650 | .651 | .652 | .653 | .655 | .656 | .657 | .658 |
| 40.......... | .6495 | .6505 | .6515 | .6525 | .6535 | .6545 | .6560 | .6570 | .6580 | .6590 |
| 42.......... | .6505 | .6515 | .6525 | .6535 | .6545 | .6555 | .6570 | .6580 | .6590 | .6600 |
| 44.......... | .6515 | .6525 | .6535 | .6545 | .6555 | .6565 | .6580 | .6590 | .6600 | .6610 |
| 46.......... | .6525 | .6535 | .6545 | .6555 | .6565 | .6575 | .6590 | .6600 | .6610 | .6620 |
| 48.......... | .6535 | .6545 | .6555 | .6565 | .6575 | .6585 | .6600 | .6610 | .6620 | .6630 |
| 50.......... | .6550 | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 |
| 52.......... | .6560 | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 |
| 64.......... | .6570 | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 |
| 56.......... | .6580 | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 |
| 58.......... | .6590 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 |
| 60.......... | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 |
| 62.......... | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 |
| 64.......... | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 |
| 66.......... | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 |
| 68.......... | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 |
| 70.......... | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 |
| 72.......... | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 |
| 74.......... | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 |
| 76.......... | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 |
| 78.......... | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 |
| 80.......... | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 |
| 82.......... | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 |
| 84.......... | .672 | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 | .681 |
| 86.......... | .673 | .674 | .675 | .676 | .677 | .678 | .679 | .680 | .681 | .682 |
| 88.......... | .674 | .675 | .676 | .677 | .678 | .679 | .679 | .680 | .681 | .682 |
| 90.......... | .675 | .676 | .677 | .678 | .679 | .680 | .680 | .681 | .682 | .683 |
| 92.......... | .676 | .677 | .678 | .679 | .680 | .681 | .681 | .682 | .683 | .684 |
| 94.......... | .677 | .678 | .679 | .680 | .681 | .682 | .682 | .683 | .684 | .685 |
| 96.......... | .678 | .679 | .680 | .681 | .682 | .683 | .683 | .684 | .685 | .686 |
| 98.......... | .679 | .680 | .681 | .682 | .683 | .684 | .684 | .685 | .686 | .687 |
| 100.......... | .680 | .681 | .682 | .683 | .684 | .685 | .685 | .686 | .687 | .688 |
| 102.......... | .681 | .682 | .683 | .684 | .685 | .686 | .686 | .687 | .688 | .689 |
| 104.......... | .682 | .683 | .684 | .685 | .686 | .687 | .687 | .688 | .689 | .690 |
| 106.......... | .683 | .684 | .685 | .686 | .687 | .688 | .688 | .689 | .690 | .691 |
| 108.......... | .683 | .684 | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 |
| 110.......... | .684 | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 |
| 112.......... | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 |
| 114.......... | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 |
| 116.......... | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 |
| 118.......... | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 |
| 120.......... | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.670 | 0.671 | 0.672 | 0.673 | 0.674 | 0.675 | 0.676 | 0.677 | 0.678 | 0.679 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.654 | 0.655 | 0.656 | 0.657 | 0.658 | 0.659 | 0.661 | 0.662 | 0.663 | 0.664 |
| 32 | .655 | .656 | .657 | .658 | .659 | .660 | .662 | .663 | .664 | .665 |
| 34 | .656 | .657 | .658 | .659 | .660 | .661 | .663 | .664 | .665 | .666 |
| 36 | .657 | .658 | .659 | .660 | .661 | .662 | .664 | .665 | .666 | .667 |
| 38 | .659 | .660 | .661 | .662 | .663 | .664 | .665 | .666 | .667 | .668 |
| 40 | .6600 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 |
| 42 | .6610 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 |
| 44 | .6620 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 |
| 46 | .6630 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 |
| 48 | .6640 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 |
| 50 | .6650 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 |
| 52 | .6660 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 |
| 54 | .6670 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 |
| 56 | .6680 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 |
| 58 | .6690 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 |
| 60 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 |
| 62 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 |
| 64 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 |
| 66 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 |
| 68 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 |
| 70 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 |
| 72 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 |
| 74 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 |
| 76 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6835 | .6845 | .6855 | .6865 |
| 78 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6845 | .6855 | .6865 | .6875 |
| 80 | .680 | .681 | .682 | .683 | .684 | .685 | .685 | .686 | .687 | .688 |
| 82 | .681 | .682 | .683 | .684 | .685 | .686 | .686 | .687 | .688 | .689 |
| 84 | .682 | .683 | .684 | .685 | .686 | .687 | .687 | .688 | .689 | .690 |
| 86 | .683 | .684 | .685 | .686 | .687 | .688 | .688 | .689 | .690 | .691 |
| 88 | .683 | .684 | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 |
| 90 | .684 | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 |
| 92 | .685 | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 |
| 94 | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 |
| 96 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 |
| 98 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 |
| 100 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 |
| 102 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 |
| 104 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 |
| 106 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 |
| 108 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 |
| 110 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 |
| 112 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 |
| 114 | .696 | .697 | .689 | .699 | .700 | .701 | .702 | .703 | .704 | .705 |
| 116 | .697 | .698 | .699 | .700 | .701 | .702 | .702 | .703 | .704 | .705 |
| 118 | .698 | .699 | .700 | .701 | .702 | .703 | .703 | .704 | .705 | .706 |
| 120 | .699 | .700 | .701 | .702 | .703 | .704 | .704 | .705 | .706 | .707 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.680 | 0.681 | 0.682 | 0.683 | 0.684 | 0.685 | 0.686 | 0.687 | 0.688 | 0.689 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.665 | 0.666 | 0.667 | 0.668 | 0.669 | 0.670 | 0.671 | 0.672 | 0.673 | 0.674 |
| 32 | .666 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 |
| 34 | .667 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 |
| 36 | .668 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 |
| 38 | .669 | .670 | .671 | .672 | .673 | .674 | .675 | .676 | .677 | .678 |
| 40 | .6700 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 |
| 42 | .6710 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 |
| 44 | .6720 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 |
| 46 | .6730 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 |
| 48 | .6740 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 |
| 50 | .6750 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 |
| 52 | .6760 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 |
| 54 | .6770 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 |
| 56 | .6780 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 |
| 58 | .6790 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 |
| 60 | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 |
| 62 | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 |
| 64 | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 |
| 66 | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 |
| 68 | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 |
| 70 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 |
| 72 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 |
| 74 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6925 | .6935 | .6945 | .6955 |
| 76 | .6875 | .6885 | .6895 | .6905 | .6915 | .6925 | .6935 | .6945 | .6955 | .6965 |
| 78 | .6885 | .6895 | .6905 | .6915 | .6925 | .6935 | .6945 | .6955 | .6965 | .6975 |
| 80 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 |
| 82 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 |
| 84 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 |
| 86 | .692 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 |
| 88 | .693 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 |
| 90 | .694 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 |
| 92 | .695 | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 |
| 94 | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 |
| 96 | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 |
| 98 | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 |
| 100 | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 |
| 102 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 |
| 104 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 | .710 |
| 106 | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 | .710 | .711 |
| 108 | .703 | .704 | .705 | .706 | .707 | .708 | .708 | .709 | .710 | .711 |
| 110 | .704 | .705 | .706 | .707 | .708 | .709 | .709 | .710 | .711 | .712 |
| 112 | .705 | .706 | .707 | .708 | .709 | .710 | .710 | .711 | .712 | .713 |
| 114 | .706 | .707 | .708 | .709 | .710 | .711 | .711 | .712 | .713 | .714 |
| 116 | .706 | .707 | .708 | .709 | .710 | .711 | .712 | .713 | .714 | .715 |
| 118 | .707 | .708 | .709 | .710 | .711 | .712 | .713 | .714 | .715 | .716 |
| 120 | .708 | .709 | .710 | .711 | .712 | .713 | .714 | .715 | .716 | .717 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.690 | 0.691 | 0.692 | 0.693 | 0.694 | 0.695 | 0.696 | 0.697 | 0.698 | 0.699 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.675 | 0.676 | 0.677 | 0.678 | 0.679 | 0.680 | 0.681 | 0.682 | 0.683 | 0.684 |
| 32.......... | .676 | .677 | .678 | .679 | .680 | .681 | .682 | .683 | .684 | .685 |
| 34.......... | .677 | .678 | .679 | .680 | .681 | .682 | .683 | .684 | .685 | .686 |
| 36.......... | .678 | .679 | .680 | .681 | .682 | .683 | .684 | .685 | .686 | .687 |
| 38.......... | .679 | .680 | .681 | .682 | .683 | .684 | .685 | .686 | .687 | .688 |
| 40.......... | .6800 | .6810 | .6820 | .6830 | .6840 | .6850 | .6865 | .6875 | .6885 | .6895 |
| 42.......... | .6810 | .6820 | .6830 | .6840 | .6850 | .6860 | .6875 | .6885 | .6895 | .6905 |
| 44.......... | .6820 | .6830 | .6840 | .6850 | .6860 | .6870 | .6885 | .6895 | .6905 | .6915 |
| 46.......... | .6830 | .6840 | .6850 | .6860 | .6870 | .6880 | .6895 | .6905 | .6915 | .6925 |
| 48.......... | .6840 | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 |
| 50.......... | .6850 | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6040 |
| 52.......... | .6860 | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 |
| 54.......... | .6870 | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 | .6960 |
| 56.......... | .6880 | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 | .6960 | .6970 |
| 58.......... | .6890 | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 | .6960 | .6970 | .6980 |
| 60.......... | .6900 | .6910 | .6920 | .6930 | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 |
| 62.......... | .6910 | .6920 | .6930 | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 |
| 64.......... | .6920 | .6930 | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 |
| 66.......... | .6930 | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 | .7020 |
| 68.......... | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 | .7020 | .7030 |
| 70.......... | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 | .7020 | .7030 | .7040 |
| 72.......... | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 | .7015 | .7025 | .7035 | .7045 |
| 74.......... | .6965 | .6975 | .6985 | .6995 | .7005 | .7015 | .7025 | .7035 | .7045 | .7055 |
| 76.......... | .6975 | .6985 | .6995 | .7005 | .7015 | .7025 | .7035 | .7045 | .7055 | .7065 |
| 78.......... | .6985 | .6995 | .7005 | .7015 | .7025 | .7035 | .7045 | .7055 | .7065 | .7075 |
| 80.......... | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 |
| 82.......... | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 |
| 84.......... | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 | .710 |
| 86.......... | .702 | .703 | .704 | .705 | .706 | .707 | .708 | .709 | .710 | .711 |
| 88.......... | .703 | .704 | .705 | .706 | .707 | .708 | .709 | .710 | .711 | .712 |
| 90.......... | .704 | .705 | .706 | .707 | .708 | .709 | .710 | .711 | .712 | .713 |
| 92.......... | .705 | .706 | .707 | .708 | .709 | .710 | .711 | .712 | .713 | .714 |
| 94.......... | .706 | .707 | .708 | .709 | .710 | .711 | .712 | .713 | .714 | .715 |
| 96.......... | .707 | .708 | .709 | .710 | .711 | .712 | .712 | .713 | .714 | .715 |
| 98.......... | .708 | .709 | .710 | .711 | .712 | .713 | .713 | .714 | .715 | .716 |
| 100.......... | .709 | .710 | .711 | .712 | .713 | .714 | .714 | .715 | .716 | .717 |
| 102.......... | .710 | .711 | .712 | .713 | .714 | .715 | .715 | .716 | .717 | .718 |
| 104.......... | .711 | .712 | .713 | .714 | .715 | .716 | .716 | .717 | .718 | .719 |
| 106.......... | .712 | .713 | .714 | .715 | .716 | .717 | .717 | .718 | .719 | .720 |
| 108.......... | .712 | .713 | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 |
| 110.......... | .713 | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 | .722 |
| 112.......... | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 | .722 | .723 |
| 114.......... | .715 | .716 | .717 | .718 | .719 | .720 | .721 | .722 | .723 | .724 |
| 116.......... | .716 | .717 | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 |
| 118.......... | .717 | .718 | .719 | .720 | .721 | .722 | .722 | .723 | .724 | .725 |
| 120.......... | .718 | .719 | .720 | .721 | .722 | .723 | .723 | .724 | .725 | .726 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.700 | 0.701 | 0.702 | 0.703 | 0.704 | 0.705 | 0.706 | 0.707 | 0.708 | 0.709 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.685 | 0.686 | 0.687 | 0.688 | 0.689 | 0.690 | 0.691 | 0.692 | 0.693 | 0.694 |
| 32.......... | .686 | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 |
| 34.......... | .687 | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 |
| 36.......... | .688 | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 |
| 38.......... | .689 | .690 | .691 | .692 | .693 | .694 | .695 | .696 | .697 | .698 |
| 40.......... | .6905 | .6915 | .6925 | .6935 | .6945 | .6955 | .6965 | .6975 | .6985 | .6995 |
| 42.......... | .6915 | .6925 | .6935 | .6945 | .6955 | .6965 | .6975 | .6985 | .6995 | .7005 |
| 44.......... | .6925 | .6935 | .6945 | .6955 | .6965 | .6975 | .6985 | .6995 | .7005 | .7015 |
| 46.......... | .6935 | .6945 | .6955 | .6965 | .6975 | .6985 | .6995 | .7005 | .7015 | .7025 |
| 48.......... | .6940 | .6950 | .6960 | .6970 | .6980 | .6990 | .7005 | .7015 | .7025 | .7035 |
| 50.......... | .6950 | .6960 | .6970 | .6980 | .6990 | .7000 | .7015 | .7025 | .7035 | .7045 |
| 52.......... | .6960 | .6970 | .6980 | .6990 | .7000 | .7010 | .7025 | .7035 | .7045 | .7055 |
| 54.......... | .6970 | .6980 | .6990 | .7000 | .7010 | .7020 | .7030 | .7040 | .7050 | .7060 |
| 56.......... | .6980 | .6990 | .7000 | .7010 | .7020 | .7030 | .7040 | .7050 | .7060 | .7070 |
| 58.......... | .6990 | .7000 | .7010 | .7020 | .7030 | .7040 | .7050 | .7060 | .7070 | .7080 |
| 60.......... | .7000 | .7010 | .7020 | .7030 | .7040 | .7050 | .7060 | .7070 | .7080 | .7090 |
| 62.......... | .7010 | .7020 | .7030 | .7040 | .7050 | .7060 | .7070 | .7080 | .7090 | .7100 |
| 64.......... | .7020 | .7030 | .7040 | .7050 | .7060 | .7070 | .7080 | .7090 | .7100 | .7110 |
| 66.......... | .7030 | .7040 | .7050 | .7060 | .7070 | .7080 | .7090 | .7100 | .7110 | .7120 |
| 68.......... | .7040 | .7050 | .7060 | .7070 | .7080 | .7090 | .7095 | .7105 | .7115 | .7125 |
| 70.......... | .7050 | .7060 | .7070 | .7080 | .7090 | .7100 | .7105 | .7115 | .7125 | .7135 |
| 72.......... | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 |
| 74.......... | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 | .7155 |
| 76.......... | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 | .7155 | .7165 |
| 78.......... | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 | .7155 | .7165 | .7175 |
| 80.......... | .709 | .710 | .711 | .712 | .713 | .714 | .715 | .716 | .717 | .718 |
| 82.......... | .710 | .711 | .712 | .713 | .714 | .715 | .716 | .717 | .718 | .719 |
| 84.......... | .711 | .712 | .713 | .714 | .715 | .716 | .717 | .718 | .719 | .720 |
| 86.......... | .712 | .713 | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 |
| 88.......... | .713 | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 | .722 |
| 90.......... | .714 | .715 | .716 | .717 | .718 | .719 | .720 | .721 | .722 | .723 |
| 92.......... | .715 | .716 | .717 | .718 | .719 | .720 | .720 | .721 | .722 | .723 |
| 94.......... | .716 | .717 | .718 | .719 | .720 | .721 | .721 | .722 | .723 | .724 |
| 96.......... | .716 | .717 | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 |
| 98.......... | .717 | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 |
| 100.......... | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 |
| 102.......... | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 |
| 104.......... | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 |
| 106.......... | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 |
| 108.......... | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 |
| 110.......... | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 |
| 112.......... | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 |
| 114.......... | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 |
| 116.......... | .726 | .727 | .728 | .729 | .730 | .731 | .731 | .732 | .733 | .734 |
| 118.......... | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 |
| 120.......... | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.710 | 0.711 | 0.712 | 0.713 | 0.714 | 0.715 | 0.716 | 0.717 | 0.718 | 0.719 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.695 | 0.696 | 0.967 | 0.698 | 0.699 | 0.700 | 0.701 | 0.702 | 0.703 | 0.704 |
| 32.......... | .696 | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 |
| 34.......... | .697 | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 |
| 36.......... | .698 | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 |
| 38.......... | .699 | .700 | .701 | .702 | .703 | .704 | .705 | .706 | .707 | .708 |
| 40.......... | .7005 | .7015 | .7025 | .7035 | .7045 | .7055 | .7065 | .7075 | .7085 | .7095 |
| 42.......... | .7015 | .7025 | .7035 | .7045 | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 |
| 44.......... | .7025 | .7035 | .7045 | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 |
| 46.......... | .7035 | .7045 | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 |
| 48.......... | .7045 | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 |
| 50.......... | .7055 | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 |
| 52.......... | .7065 | .7075 | .7085 | .7095 | .7105 | .7115 | .7125 | .7135 | .7145 | .7155 |
| 54.......... | .7070 | .7080 | .7090 | .7100 | .7100 | .7120 | .7130 | .7140 | .7150 | .7160 |
| 56.......... | .7080 | .7090 | .7100 | .7110 | .7120 | .7130 | .7140 | .7150 | .7160 | .7170 |
| 58.......... | .7090 | .7100 | .7110 | .7120 | .7130 | .7140 | .7150 | .7160 | .7170 | .7180 |
| 60.......... | .7100 | .7110 | .7120 | .7130 | .7140 | .7150 | .7160 | .7170 | .7180 | .7190 |
| 62.......... | .7110 | .7120 | .7130 | .7140 | .7150 | .7160 | .7170 | .7180 | .7190 | .7200 |
| 64.......... | .7120 | .7130 | .7140 | .7150 | .7160 | .7170 | .7180 | .7190 | .7200 | .7210 |
| 66.......... | .7130 | .7140 | .7150 | .7160 | .7170 | .7180 | .7185 | .7195 | .7205 | .7215 |
| 68.......... | .7135 | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 |
| 70.......... | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 |
| 72.......... | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 |
| 74.......... | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 | .7255 |
| 76.......... | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 | .7255 | .7265 |
| 78.......... | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 | .7255 | .7265 | .7275 |
| 80.......... | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 |
| 82.......... | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 |
| 84.......... | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 |
| 86.......... | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 |
| 88.......... | .723 | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 |
| 90.......... | .724 | .725 | .726 | .727 | .728 | .729 | .729 | .730 | .731 | .732 |
| 92.......... | .724 | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 |
| 94.......... | .725 | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 |
| 96.......... | .726 | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 |
| 98.......... | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 |
| 100.......... | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 |
| 102.......... | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 |
| 104.......... | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 | .739 |
| 106.......... | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 | .739 | .740 |
| 108.......... | .732 | .733 | .734 | .735 | .736 | .737 | .737 | .738 | .739 | .740 |
| 110.......... | .733 | .734 | .735 | .736 | .737 | .738 | .738 | .739 | .740 | .741 |
| 112.......... | .734 | .735 | .736 | .737 | .738 | .739 | .739 | .740 | .741 | .742 |
| 114.......... | .734 | .735 | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 |
| 116.......... | .735 | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 |
| 118.......... | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 | .745 |
| 120.......... | .737 | .738 | .739 | .740 | .741 | .742 | .742 | .743 | .744 | .745 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.720 | 0.721 | 0.722 | 0.723 | 0.724 | 0.725 | 0.726 | 0.727 | 0.728 | 0.729 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.705 | 0.706 | 0.707 | 0.708 | 0.709 | 0.710 | 0.712 | 0.713 | 0.714 | 0.715 |
| 32.......... | .706 | .707 | .708 | .709 | .710 | .711 | .713 | .714 | .715 | .716 |
| 34.......... | .707 | .708 | .709 | .710 | .711 | .712 | .714 | .715 | .716 | .717 |
| 36.......... | .708 | .709 | .710 | .711 | .712 | .713 | .715 | .716 | .717 | .718 |
| 38.......... | .709 | .710 | .711 | .712 | .713 | .714 | .716 | .717 | .718 | .719 |
| 40.......... | .7105 | .7115 | .7125 | .7135 | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 |
| 42.......... | .7115 | .7125 | .7135 | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 |
| 44.......... | .7125 | .7135 | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 |
| 46.......... | .7135 | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 |
| 48.......... | .7145 | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 |
| 50.......... | .7155 | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 |
| 52.......... | .7165 | .7175 | .7185 | .7195 | .7205 | .7215 | .7225 | .7235 | .7245 | .7255 |
| 54.......... | .7170 | .7180 | .7190 | .7200 | .7210 | .7220 | .7230 | .7240 | .7250 | .7260 |
| 56.......... | .7180 | .7190 | .7200 | .7210 | .7220 | .7230 | .7240 | .7250 | .7260 | .7270 |
| 58.......... | .7190 | .7200 | .7210 | .7220 | .7230 | .7240 | .7250 | .7260 | .7270 | .7280 |
| 60.......... | .7200 | .7210 | .7220 | .7230 | .7240 | .7250 | .7260 | .7270 | .7280 | .7290 |
| 62.......... | .7210 | .7220 | .7230 | .7240 | .7250 | .7260 | .7270 | .7280 | .7290 | .7300 |
| 64.......... | .7220 | .7230 | .7240 | .7250 | .7260 | .7270 | .7280 | .7290 | .7300 | .7310 |
| 66.......... | .7225 | .7235 | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 |
| 68.......... | .7235 | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 |
| 70.......... | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 |
| 72.......... | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 | .7345 |
| 74.......... | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 | .7345 | .7355 |
| 76.......... | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7330 | .7340 | .7350 | .7360 |
| 78.......... | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 | .7340 | .7350 | .7360 | .7370 |
| 80.......... | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 |
| 82.......... | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 | .739 |
| 84.......... | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 | .739 | .740 |
| 86.......... | .732 | .733 | .734 | .735 | .736 | .737 | .737 | .738 | .739 | .740 |
| 88.......... | .733 | .734 | .735 | .736 | .737 | .738 | .738 | .739 | .740 | .741 |
| 90.......... | .733 | .734 | .735 | .736 | .737 | .738 | .739 | .740 | .741 | .742 |
| 92.......... | .734 | .735 | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 |
| 94.......... | .735 | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 |
| 96.......... | .736 | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 | .745 |
| 98.......... | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 | .745 | .746 |
| 100.......... | .738 | .739 | .740 | .741 | .742 | .743 | .743 | .744 | .745 | .746 |
| 102.......... | .739 | .740 | .741 | .742 | .743 | .744 | .744 | .745 | .746 | .747 |
| 104.......... | .740 | .741 | .742 | .743 | .744 | .745 | .745 | .746 | .747 | .748 |
| 106.......... | .741 | .742 | .743 | .744 | .745 | .746 | .746 | .747 | .748 | .749 |
| 108.......... | .741 | .742 | .743 | .744 | .745 | .746 | .747 | .748 | .749 | .750 |
| 110.......... | .742 | .743 | .744 | .745 | .746 | .747 | .748 | .749 | .750 | .751 |
| 112.......... | .743 | .744 | .745 | .746 | .747 | .748 | .749 | .750 | .751 | .752 |
| 114.......... | .744 | .745 | .746 | .747 | .748 | .749 | .749 | .750 | .751 | .752 |
| 116.......... | .745 | .746 | .747 | .748 | .749 | .750 | .750 | .751 | .752 | .753 |
| 118.......... | .746 | .747 | .748 | .749 | .750 | .751 | .751 | .752 | .753 | .754 |
| 120.......... | .746 | .747 | .748 | .749 | .750 | .751 | .752 | .753 | .754 | .755 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.730 | 0.731 | 0.732 | 0.733 | 0.734 | 0.735 | 0.736 | 0.737 | 0.738 | 0.739 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.716 | 0.717 | 0.718 | 0.719 | 0.720 | 0.721 | 0.722 | 0.723 | 0.724 | 0.725 |
| 32.......... | .717 | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 |
| 34.......... | .718 | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 |
| 36.......... | .719 | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 |
| 38.......... | .720 | .721 | .722 | .723 | .724 | .725 | .726 | .727 | .728 | .729 |
| 40.......... | .7205 | .7215 | .7225 | .7235 | .7245 | .7255 | .7270 | .7280 | .7290 | .7300 |
| 42.......... | .7215 | .7225 | .7235 | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 |
| 44.......... | .7225 | .7235 | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | 7305 | .7315 |
| 46.......... | .7235 | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 |
| 48.......... | .7245 | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 |
| 50.......... | .7255 | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 | .7345 |
| 52.......... | .7265 | .7275 | .7285 | .7295 | .7305 | .7315 | .7325 | .7335 | .7345 | .7355 |
| 54.......... | .7270 | .7280 | .7290 | .7300 | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 |
| 56.......... | .7280 | .7290 | .7300 | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 |
| 58.......... | .7290 | .7300 | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 | .7380 |
| 60.......... | .7300 | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 | .7380 | .7390 |
| 62.......... | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 | .7380 | .7390 | .7400 |
| 64.......... | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 | .7375 | .7385 | .7395 | .7405 |
| 66.......... | .7325 | .7335 | .7345 | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 |
| 68.......... | .7335 | .7345 | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7425 |
| 70.......... | .7345 | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7425 | .7435 |
| 72.......... | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7410 | .7420 | .7430 | .7440 |
| 74.......... | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7420 | .7430 | .7440 | .7450 |
| 76.......... | .7370 | .7380 | .7390 | .7400 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 |
| 78.......... | .7380 | .7390 | .7400 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 |
| 80.......... | .739 | .740 | .741 | .742 | .743 | .744 | .744 | .745 | .746 | .747 |
| 82.......... | .740 | .741 | .742 | .743 | .744 | .745 | .745 | .746 | .747 | .748 |
| 84.......... | .741 | .742 | .743 | .744 | .745 | .746 | .746 | .747 | .748 | .749 |
| 86.......... | .741 | .742 | .743 | .744 | .745 | .746 | .747 | .748 | .749 | .750 |
| 88.......... | .742 | .743 | .744 | .745 | .746 | .747 | .748 | .749 | .750 | .751 |
| 90.......... | 7.43 | .744 | .745 | .746 | .747 | .748 | .749 | .750 | .751 | .752 |
| 92.......... | .744 | .745 | .746 | .747 | .748 | .749 | .750 | .751 | .752 | .753 |
| 94.......... | .745 | .746 | .747 | .748 | .749 | .750 | .751 | .752 | .753 | .754 |
| 96.......... | .746 | .747 | .748 | .749 | .750 | .751 | .751 | .752 | .753 | .754 |
| 98.......... | .747 | .748 | .749 | .750 | .751 | .752 | .752 | .753 | .754 | .755 |
| 100.......... | .747 | .748 | .749 | .750 | .751 | .752 | .753 | .754 | .755 | .756 |
| 102.......... | .748 | .749 | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 |
| 104.......... | .749 | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 | .758 |
| 106.......... | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 | .758 | .759 |
| 108.......... | .751 | .752 | .753 | .754 | .755 | .756 | .756 | .757 | .758 | .759 |
| 110.......... | .752 | .753 | .754 | .755 | .756 | .757 | .757 | .758 | .759 | .760 |
| 112.......... | .753 | .754 | .755 | .756 | .757 | .758 | .758 | .759 | .760 | .761 |
| 114.......... | .753 | .754 | .755 | .756 | .757 | .758 | .759 | .760 | .761 | .762 |
| 116.......... | .754 | .755 | .756 | .757 | .758 | .759 | .760 | .761 | .762 | .763 |
| 118.......... | .755 | .756 | .757 | .758 | .759 | .760 | .761 | .762 | .763 | .764 |
| 120.......... | .756 | .757 | .758 | .759 | .760 | .761 | .761 | .762 | .763 | .764 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.740 | 0.741 | 0.742 | 0.743 | 0.744 | 0.745 | 0.746 | 0.747 | 0.748 | 0.749 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.726 | 0.727 | 0.728 | 0.729 | 0.730 | 0.731 | 0.732 | 0.733 | 0.734 | 0.735 |
| 32.......... | .727 | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 |
| 34.......... | .728 | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 |
| 36.......... | .729 | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 |
| 38.......... | .730 | .731 | .732 | .733 | .734 | .735 | .736 | .737 | .738 | .739 |
| 40.......... | .7310 | .7320 | .7330 | .7340 | .7350 | .7360 | .7370 | .7380 | .7390 | .7400 |
| 42.......... | .7315 | .7325 | .7335 | .7345 | .7355 | .7365 | .7380 | .7390 | .7400 | .7410 |
| 44.......... | .7325 | .7335 | .7345 | .7355 | .7365 | .7375 | .7390 | .7400 | .7410 | .7420 |
| 46.......... | .7335 | .7345 | .7355 | .7365 | .7375 | .7385 | .7400 | .7410 | .7420 | .7430 |
| 48.......... | .7345 | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7425 | .7435 |
| 50.......... | .7355 | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7425 | .7435 | .7445 |
| 52.......... | .7365 | .7375 | .7385 | .7395 | .7405 | .7415 | .7425 | .7435 | .7445 | .7455 |
| 54.......... | .7370 | .7380 | .7390 | .7400 | .7410 | .7420 | .7435 | .7445 | .7455 | .7465 |
| 56.......... | .7380 | .7390 | .7400 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 |
| 58.......... | .7390 | .7400 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 | .7480 |
| 60.......... | .7400 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 | .7480 | .7490 |
| 62.......... | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 | .7480 | .7490 | .7500 |
| 64.......... | .7415 | .7425 | .7435 | .7445 | .7455 | .7465 | .7475 | .7485 | .7495 | .7505 |
| 66.......... | .7425 | .7435 | .7445 | .7455 | .7465 | .7475 | .7485 | .7495 | .7505 | .7515 |
| 68.......... | .7435 | .7445 | .7455 | .7465 | .7475 | .7485 | .7495 | .7505 | .7515 | .7525 |
| 70.......... | .7445 | .7455 | .7465 | .7475 | .7485 | .7495 | .7505 | .7515 | .7525 | .7535 |
| 72.......... | .7450 | .7460 | .7470 | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 |
| 74.......... | .7460 | .7470 | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 |
| 76.......... | .7470 | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 |
| 78.......... | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 |
| 80.......... | .748 | .749 | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 |
| 82.......... | .749 | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 | .758 |
| 84.......... | .750 | .751 | .752 | .753 | .754 | .755 | .756 | .757 | .758 | .759 |
| 86.......... | .751 | .752 | .753 | .754 | .755 | .756 | .757 | .758 | .759 | .760 |
| 88.......... | .752 | .753 | .754 | .755 | .756 | .757 | .758 | .759 | .760 | .761 |
| 90.......... | .753 | .754 | .755 | .756 | .757 | .758 | .759 | .760 | .761 | .762 |
| 92.......... | .754 | .755 | .756 | .757 | .758 | .759 | .759 | .760 | .761 | .762 |
| 94.......... | .755 | .756 | .757 | .758 | .759 | .760 | .760 | .761 | .762 | .763 |
| 96.......... | .755 | .756 | .757 | .758 | .759 | .760 | .761 | .762 | .763 | .764 |
| 98.......... | .756 | .757 | .758 | .759 | .760 | .761 | .762 | .763 | .764 | .765 |
| 100.......... | .757 | .758 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 |
| 102.......... | .758 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 |
| 104.......... | .759 | .760 | .761 | .762 | .763 | .764 | .764 | .765 | .676 | .767 |
| 106.......... | .760 | .761 | .762 | .763 | .764 | .765 | .765 | .766 | .767 | .768 |
| 108.......... | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 |
| 110.......... | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 | .770 |
| 112.......... | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 | .770 | .771 |
| 114.......... | .763 | .764 | .765 | .766 | .767 | .768 | .768 | .769 | .770 | .771 |
| 116.......... | .764 | .765 | .766 | .767 | .768 | .769 | .769 | .770 | .771 | .772 |
| 118.......... | .765 | .766 | .767 | .768 | .769 | .770 | .770 | .771 | .772 | .773 |
| 120.......... | .765 | .766 | .767 | .768 | .769 | .770 | .771 | .772 | .773 | .774 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.750 | 0.751 | 0.752 | 0.753 | 0.754 | 0.755 | 0.756 | 0.757 | 0.758 | 0.759 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.736 | 0.737 | 0.738 | 0.739 | 0.740 | 0.741 | 0.742 | 0.743 | 0.744 | 0.745 |
| 32 | .737 | .738 | .739 | .740 | .741 | .742 | .743 | .744 | .745 | .746 |
| 34 | .738 | .739 | .740 | .741 | .742 | .743 | .744 | .745 | .746 | .747 |
| 36 | .739 | .740 | .741 | .742 | .743 | .744 | .745 | .746 | .747 | .748 |
| 38 | .740 | .741 | .742 | .743 | .744 | .745 | .746 | .747 | .748 | .749 |
| 40 | .7410 | .7420 | .7430 | .7440 | .7450 | .7460 | .7475 | .7485 | .7495 | .7505 |
| 42 | .7420 | .7430 | .7440 | .7450 | .7460 | .7470 | .7480 | .7490 | .7500 | .7510 |
| 44 | .7430 | .7440 | .7450 | .7460 | .7470 | .7480 | .7490 | .7500 | .7510 | .7520 |
| 46 | .7440 | .7450 | .7460 | .7470 | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 |
| 48 | .7445 | .7455 | .7465 | .7475 | .7485 | .7495 | .7510 | .7520 | .7530 | .7540 |
| 50 | .7455 | .7465 | .7475 | .7485 | .7495 | .7505 | .7515 | .7525 | .7535 | .7545 |
| 52 | .7465 | .7475 | .7485 | .7495 | .7505 | .7515 | .7525 | .7535 | .7545 | .7555 |
| 54 | .7475 | .7485 | .7495 | .7505 | .7515 | .7525 | .7535 | .7545 | .7555 | .7565 |
| 56 | .7480 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 |
| 58 | .7490 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 | .7580 |
| 60 | .7500 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 | .7580 | .7590 |
| 62 | .7510 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 | .7580 | .7590 | .7600 |
| 64 | .7515 | .7525 | .7535 | .7545 | .7555 | .7565 | .7575 | .7585 | .7595 | .7605 |
| 66 | .7525 | .7535 | .7545 | .7555 | .7565 | .7575 | .7585 | .7595 | .7605 | .7615 |
| 68 | .7535 | .7545 | .7555 | .7565 | .7575 | .7585 | .7590 | .7600 | .7610 | .7620 |
| 70 | .7545 | .7555 | .7565 | .7575 | .7585 | .7595 | .7600 | .7610 | .7620 | .7630 |
| 72 | .7550 | .7560 | .7570 | .7580 | .7590 | .7600 | .7610 | .7620 | .7630 | .7640 |
| 74 | .7560 | .7570 | .7580 | .7590 | .7600 | .7610 | .7615 | .7625 | .7635 | .7645 |
| 76 | .7570 | .7580 | .7590 | .7600 | .7610 | .7620 | .7625 | .7635 | .7645 | .7655 |
| 78 | .7580 | .7590 | .7600 | .7610 | .7620 | .7630 | .7635 | .7645 | .7655 | .7665 |
| 80 | .758 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 |
| 82 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 |
| 84 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 |
| 86 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 | .770 |
| 88 | .762 | .763 | .764 | .765 | .766 | .767 | .767 | .768 | .769 | .770 |
| 90 | .763 | .764 | .765 | .766 | .767 | .768 | .768 | .769 | .770 | .771 |
| 92 | .763 | .764 | .765 | .766 | .767 | .768 | .769 | .770 | .771 | .772 |
| 94 | .764 | .765 | .766 | .767 | .768 | .769 | .770 | .771 | .772 | .773 |
| 96 | .765 | .766 | .767 | .768 | .769 | .770 | .771 | .772 | .773 | .774 |
| 98 | .766 | .767 | .768 | .769 | .770 | .771 | .771 | .772 | .773 | .774 |
| 100 | .767 | .768 | .769 | .770 | .771 | .772 | .772 | .773 | .774 | .775 |
| 102 | .768 | .769 | .770 | .771 | .772 | .773 | .773 | .774 | .775 | .776 |
| 104 | .768 | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 |
| 106 | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 |
| 108 | .770 | .771 | .772 | .773 | .774 | .775 | .775 | .776 | .777 | .778 |
| 110 | .771 | .772 | .773 | .774 | .775 | .776 | .776 | .777 | .778 | .779 |
| 112 | .772 | .773 | .774 | .775 | .776 | .777 | .777 | .778 | .779 | .780 |
| 114 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 |
| 116 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 | .782 |
| 118 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 | .782 | .783 |
| 120 | .775 | .776 | .777 | .778 | .779 | .780 | .780 | .781 | .782 | .783 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.760 | 0.761 | 0.762 | 0.763 | 0.764 | 0.765 | 0.766 | 0.767 | 0.768 | 0.769 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.746 | 0.747 | 0.748 | 0.749 | 0.750 | 0.751 | 0.753 | 0.754 | 0.755 | 0.756 |
| 32 | .747 | .748 | .749 | .750 | .751 | .752 | .754 | .755 | .756 | .757 |
| 34 | .748 | .749 | .750 | .751 | .752 | .753 | .755 | .756 | .757 | .758 |
| 36 | .749 | .750 | .751 | .752 | .753 | .754 | .756 | .757 | .758 | .759 |
| 38 | .750 | .751 | .752 | .753 | .754 | .755 | .757 | .758 | .759 | .760 |
| 40 | .7515 | .7525 | .7535 | .7545 | .7555 | .7565 | .7575 | .7585 | .7595 | .7605 |
| 42 | .7520 | .7530 | .7540 | .7550 | .7560 | .7570 | .7585 | .7595 | .7605 | .7615 |
| 44 | .7530 | .7540 | .7550 | .7560 | .7570 | .7580 | .7590 | .7600 | .7610 | .7620 |
| 46 | .7540 | .7550 | .7560 | .7570 | .7580 | .7590 | .7600 | .7610 | .7620 | .7630 |
| 48 | .7550 | .7560 | .7570 | .7580 | .7590 | .7600 | .7610 | .7620 | .7630 | .7640 |
| 50 | .7555 | .7565 | .7575 | .7585 | .7595 | .7605 | .7620 | .7630 | .7640 | .7650 |
| 52 | .7565 | .7575 | .7585 | .7595 | .7605 | .7615 | .7625 | .7635 | .7645 | .7655 |
| 54 | .7575 | .7585 | .7595 | .7605 | .7615 | .7625 | .7635 | .7645 | .7655 | .7665 |
| 56 | .7580 | .7590 | .7600 | .7610 | .7620 | .7630 | .7645 | .7655 | .7665 | .7675 |
| 58 | .7590 | .7600 | .7610 | .7620 | .7630 | .7640 | .7650 | .7660 | .7670 | .7680 |
| 60 | .7600 | .7610 | .7620 | .7630 | .7640 | .7650 | .7660 | .7670 | .7680 | .7690 |
| 62 | .7610 | .7620 | .7630 | .7640 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 |
| 64 | .7615 | .7025 | .7635 | .7645 | .7655 | .7665 | .7675 | .7685 | .7695 | .7705 |
| 66 | .7625 | .7635 | .7645 | .7655 | .7665 | .7675 | .7685 | .7695 | .7705 | .7715 |
| 68 | .7630 | .7640 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 |
| 70 | .7640 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 | .7730 |
| 72 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 | .7730 | .7740 |
| 74 | .7655 | .7665 | .7675 | .7685 | .7695 | .7705 | .7715 | .7725 | .7735 | .7745 |
| 76 | .7665 | .7675 | .7685 | .7695 | .7705 | .7715 | .7725 | .7735 | .7745 | .7755 |
| 78 | .7675 | .7685 | .7695 | .7705 | .7715 | .7725 | .7735 | .7745 | .7755 | .7765 |
| 80 | .768 | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 |
| 82 | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 |
| 84 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 |
| 86 | .771 | .772 | .773 | .774 | .775 | .776 | .776 | .777 | .778 | .778 |
| 88 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 |
| 90 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 |
| 92 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 | .782 |
| 94 | .774 | .775 | .776 | .777 | .778 | .779 | .780 | .781 | .782 | .783 |
| 96 | .775 | .776 | .777 | .778 | .779 | .780 | .780 | .781 | .782 | .783 |
| 98 | .775 | .776 | .777 | .778 | .779 | .780 | .781 | .782 | .783 | .784 |
| 100 | .776 | .777 | .778 | .779 | .780 | .781 | .782 | .783 | .784 | .785 |
| 102 | .777 | .778 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 |
| 104 | .778 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 |
| 106 | .779 | .780 | .781 | .782 | .783 | .784 | .784 | .785 | .786 | .787 |
| 108 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 |
| 110 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 |
| 112 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 | .790 |
| 114 | .782 | .783 | .784 | .785 | .786 | .787 | .787 | .788 | .789 | .790 |
| 116 | .783 | .784 | .785 | .786 | .787 | .788 | .788 | .789 | .790 | .791 |
| 118 | .784 | .785 | .786 | .787 | .788 | .789 | .789 | .790 | .791 | .792 |
| 120 | .784 | .785 | .786 | .787 | .788 | .789 | .790 | .791 | .792 | .793 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.770 | 0.771 | 0.772 | 0.773 | 0.774 | 0.775 | 0.776 | 0.777 | 0.778 | 0.779 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.757 | 0.758 | 0.759 | 0.760 | 0.761 | 0.762 | 0.763 | 0.764 | 0.765 | 0.766 |
| 32 | .758 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 |
| 34 | .759 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 |
| 36 | .760 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 |
| 38 | .761 | .762 | .763 | .764 | .765 | .766 | .767 | .768 | .769 | .770 |
| 40 | .7615 | .7625 | .7635 | .7645 | .7655 | .7665 | .7675 | .7685 | .7695 | .7705 |
| 42 | .7625 | .7635 | .7645 | .7655 | .7665 | .7675 | .7685 | .7695 | .7705 | .7715 |
| 44 | .7630 | .7640 | .7650 | .7665 | .7670 | .7680 | .7695 | .7705 | .7715 | .7725 |
| 46 | .7640 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 | .7730 |
| 48 | .7650 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 | .7730 | .7740 |
| 50 | .7660 | .7670 | .7680 | .7690 | .7700 | .7710 | .7720 | .7730 | .7740 | .7750 |
| 52 | .7665 | .7675 | .7685 | .7695 | .7705 | .7715 | 7725 | .7735 | .7745 | .7755 |
| 54 | .7675 | .7685 | .7695 | .7705 | .7715 | .7725 | .7735 | .7745 | .7755 | .7765 |
| 56 | .7685 | .7695 | .7705 | .7715 | 7725 | .7735 | .7745 | .7755 | .7765 | .7775 |
| 58 | .7690 | .7700 | .7710 | .7720 | .7730 | .7740 | .7750 | .7760 | .7770 | .7780 |
| 60 | .7700 | .7710 | .7720 | .7730 | .7740 | .7750 | .7760 | .7770 | .7780 | .7790 |
| 62 | .7710 | .7720 | .7730 | .7740 | .7750 | .7760 | .7770 | .7780 | .7790 | .7800 |
| 64 | .7715 | .7725 | .7735 | .7745 | .7755 | .7765 | .7775 | .7785 | .7795 | .7805 |
| 66 | .7725 | .7735 | .7745 | .7755 | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 |
| 68 | .7730 | .7740 | .7750 | .7760 | .7770 | .7780 | .7790 | .7800 | .7810 | .7820 |
| 70 | .7740 | .7750 | .7760 | .7770 | .7780 | .7790 | .7800 | .7810 | .7820 | .7830 |
| 72 | .7750 | .7760 | .7770 | .7780 | .7790 | .7800 | .7810 | .7820 | .7830 | .7840 |
| 74 | .7755 | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 | .7825 | .7835 | .7845 |
| 76 | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 | .7825 | .7835 | .7845 | .7855 |
| 78 | .7775 | .7785 | .7795 | .7805 | .7815 | .7825 | .7835 | .7845 | .7855 | .7865 |
| 80 | .778 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 |
| 82 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 |
| 84 | .780 | .781 | .782 | .783 | .784 | .785 | .785 | .786 | .787 | .788 |
| 86 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 |
| 88 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 | .790 |
| 90 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 | .790 | .791 |
| 92 | .783 | .784 | .785 | .786 | .787 | .788 | .789 | .790 | .791 | .792 |
| 94 | .784 | .785 | .786 | .787 | .788 | .789 | .789 | .790 | .791 | .792 |
| 96 | .784 | .785 | .786 | .787 | .788 | .789 | .790 | .791 | .792 | .793 |
| 98 | .785 | .786 | .787 | .788 | .789 | .790 | .791 | .792 | .793 | .794 |
| 100 | .786 | .787 | .788 | .789 | .790 | .791 | .792 | .793 | .794 | .795 |
| 102 | .787 | .788 | .789 | .790 | .791 | .792 | .792 | .793 | .794 | .795 |
| 104 | .788 | .789 | .790 | .791 | .792 | .793 | .793 | .794 | .795 | .796 |
| 106 | .788 | .789 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 |
| 108 | .789 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 |
| 110 | .790 | .791 | .792 | .793 | .794 | .795 | .795 | .796 | .797 | .798 |
| 112 | .791 | .792 | .793 | .794 | .795 | .796 | .796 | .797 | .798 | .799 |
| 114 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 |
| 116 | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 | .801 |
| 118 | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 | .801 | .802 |
| 120 | .794 | .795 | .796 | .797 | .798 | .799 | .799 | .800 | .801 | .802 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.780 | 0.781 | 0.782 | 0.783 | 0.784 | 0.785 | 0.786 | 0.787 | 0.788 | 0.789 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.767 | 0.768 | 0.769 | 0.770 | 0.771 | 0.772 | 0.773 | 0.774 | 0.775 | 0.776 |
| 32.......... | .768 | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 |
| 34.......... | .769 | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 |
| 36.......... | .770 | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 |
| 38.......... | .771 | .772 | .773 | .774 | .775 | .776 | .777 | .778 | .779 | .780 |
| 40.......... | .7715 | .7725 | .7735 | .7745 | .7755 | .7765 | .7780 | .7790 | .7800 | .7810 |
| 42.......... | .7725 | .7735 | .7745 | .7755 | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 |
| 44.......... | .7735 | .7745 | .7755 | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 | .7825 |
| 46.......... | .7740 | .7750 | .7760 | .7770 | .7780 | .7790 | .7805 | .7815 | .7825 | .7835 |
| 48.......... | .7750 | .7760 | .7770 | .7780 | .7790 | .7800 | .7810 | .7820 | .7830 | .7840 |
| 50.......... | .7760 | .7770 | .7780 | .7790 | .7800 | .7810 | .7820 | .7830 | .7840 | .7850 |
| 52.......... | .7765 | .7775 | .7785 | .7795 | .7805 | .7815 | .7830 | .7840 | .7850 | .7860 |
| 54.......... | .7775 | .7785 | .7795 | .7805 | .7815 | .7825 | .7835 | .7845 | .7855 | .7865 |
| 56.......... | .7785 | .7795 | .7805 | .7815 | .7825 | .7835 | .7845 | .7855 | .7865 | .7875 |
| 58.......... | .7790 | .7800 | .7810 | .7820 | .7830 | .7840 | .7850 | .7860 | .7870 | .7880 |
| 60.......... | .7800 | .7810 | .7820 | .7830 | .7840 | .7850 | .7860 | .7870 | .7880 | .7890 |
| 62.......... | .7810 | .7820 | .7830 | .7840 | .7850 | .7860 | .7865 | .7875 | .7885 | .7895 |
| 64.......... | .7815 | .7825 | .7835 | .7845 | .7855 | .7865 | .7875 | .7885 | .7895 | .7905 |
| 66.......... | .7825 | .7835 | .7845 | .7855 | .7865 | .7875 | .7885 | .7895 | .7905 | .7915 |
| 68.......... | .7830 | .7840 | .7850 | .7860 | .7870 | .7880 | .7890 | .7900 | .7910 | .7920 |
| 70.......... | .7840 | .7850 | .7860 | .7870 | .7880 | .7890 | .7900 | .7910 | .7920 | .7930 |
| 72.......... | .7850 | .7860 | .7870 | .7880 | .7890 | .7900 | .7905 | .7915 | .7925 | .7935 |
| 74.......... | .7855 | .7865 | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 | .7935 | .7945 |
| 76.......... | .7865 | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 | .7935 | .7945 | .7955 |
| 78.......... | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 | .7930 | .7940 | .7450 | .7960 |
| 80.......... | .788 | .789 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 |
| 82.......... | .789 | .790 | .791 | .792 | .793 | .794 | .794 | .795 | .796 | .797 |
| 84.......... | .789 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 |
| 86.......... | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 |
| 88.......... | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 |
| 90.......... | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 | .801 |
| 92.......... | .793 | .794 | .795 | .796 | .797 | .798 | .798 | .799 | .800 | .801 |
| 94.......... | .793 | .794 | .795 | .796 | .797 | .798 | .799 | .800 | .801 | .802 |
| 96.......... | .794 | .795 | .796 | .797 | .798 | .799 | .800 | .801 | .802 | .803 |
| 98.......... | .795 | .796 | .797 | .798 | .799 | .800 | .801 | .802 | .803 | .804 |
| 100.......... | .796 | .797 | .798 | .799 | .800 | .801 | .801 | .802 | .803 | .804 |
| 102.......... | .796 | .797 | .798 | .799 | .800 | .801 | .802 | .803 | .804 | .805 |
| 104.......... | .797 | .798 | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 |
| 106.......... | .798 | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 |
| 108.......... | .799 | .800 | .801 | .802 | .803 | .804 | .804 | .805 | .806 | .807 |
| 110.......... | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 |
| 112.......... | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 | .809 |
| 114.......... | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 | .809 | .810 |
| 116.......... | .802 | .803 | .804 | .805 | .806 | .807 | .807 | .808 | .809 | .810 |
| 118.......... | .803 | .804 | .805 | .806 | .807 | .808 | .808 | .809 | .810 | .811 |
| 120.......... | .803 | .804 | .805 | .806 | .807 | .808 | .809 | .810 | .811 | .812 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.790 | 0.791 | 0.792 | 0.793 | 0.794 | 0.795 | 0.796 | 0.797 | 0.798 | 0.799 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.777 | .0778 | 0.779 | 0.780 | 0.781 | 0.782 | 0.784 | 0.785 | 0.786 | 0.787 |
| 32.......... | .778 | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 |
| 34.......... | .779 | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 |
| 36.......... | .780 | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 |
| 38.......... | .781 | .782 | .783 | .784 | .785 | .786 | .787 | .788 | .789 | .790 |
| 40.......... | .7820 | .7830 | .7840 | .7850 | .7860 | .7870 | .7880 | .7890 | .7900 | .7910 |
| 42.......... | .7825 | .7835 | .7845 | .7855 | .7865 | .7875 | .7890 | .7900 | .7910 | .7920 |
| 44.......... | .7835 | .7845 | .7855 | .7865 | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 |
| 46.......... | .7845 | .7855 | .7865 | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 | .7935 |
| 48.......... | .7850 | .7860 | .7870 | .7880 | .7890 | .7900 | .7910 | .7920 | .7930 | .7940 |
| 50.......... | .7860 | .7870 | .7880 | .7890 | .7900 | .7910 | .7920 | .7930 | .7940 | .7950 |
| 52.......... | .7870 | .7880 | .7890 | .7900 | .7910 | .7920 | .7930 | .7940 | .7950 | .7960 |
| 54.......... | .7875 | .7885 | .7895 | .7905 | .7915 | .7925 | .7935 | .7945 | .7955 | .7965 |
| 56.......... | .7885 | .7895 | .7905 | .7915 | .7925 | .7935 | .7945 | .7955 | .7965 | .7975 |
| 58.......... | .7890 | .7900 | .7910 | .7920 | .7930 | .7940 | .7955 | .7965 | .7975 | .7985 |
| 60.......... | .7900 | .7910 | .7920 | .7930 | .7940 | .7950 | .7960 | .7970 | .7980 | .7990 |
| 62.......... | .7905 | .7915 | .7925 | .7935 | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 |
| 64.......... | .7915 | .7925 | .7935 | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 |
| 66.......... | .7925 | .7935 | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 |
| 68.......... | .7930 | .7940 | .7950 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 |
| 70.......... | .7940 | .7950 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 | .8030 |
| 72.......... | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 | .8025 | .8035 |
| 74.......... | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 | .8025 | .8035 | .8045 |
| 76.......... | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 | .8020 | .8030 | .8040 | .8050 |
| 78.......... | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 | .8030 | .8040 | .8050 | .8000 |
| 80.......... | .798 | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 |
| 82.......... | .798 | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 |
| 84.......... | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 |
| 86.......... | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 | .809 |
| 88.......... | .801 | .802 | .803 | .804 | 805 | .806 | .807 | .808 | .809 | .810 |
| 90.......... | .802 | .803 | .804 | .805 | .806 | .807 | .808 | .809 | .810 | .811 |
| 92.......... | .802 | .803 | .804 | .805 | .806 | .807 | .808 | .809 | .810 | .811 |
| 94.......... | .803 | .804 | .805 | .806 | .807 | .808 | .809 | .810 | .811 | .812 |
| 96.......... | .804 | .805 | .806 | .807 | .808 | .809 | .810 | .811 | .812 | .813 |
| 98.......... | .805 | .806 | .807 | .808 | .809 | .810 | .811 | .812 | .813 | .814 |
| 100.......... | .805 | .806 | .807 | .808 | .809 | .810 | .811 | .812 | .813 | .814 |
| 102.......... | .806 | .807 | .808 | .809 | .810 | .811 | .812 | .813 | .814 | .815 |
| 104.......... | .807 | .808 | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 |
| 106.......... | .808 | .809 | .810 | .811 | .812 | .813 | .813 | .814 | .815 | .816 |
| 108.......... | .808 | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 |
| 110.......... | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 |
| 112.......... | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 |
| 114.......... | .811 | .812 | .813 | .814 | .815 | .816 | .816 | .817 | .818 | .819 |
| 116.......... | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 |
| 118.......... | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 | .821 |
| 120.......... | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 | .821 | .822 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.800 | 0.801 | 0.802 | 0.803 | 0.804 | 0.805 | 0.806 | 0.807 | 0.808 | 0.809 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.788 | 0.789 | 0.790 | 0.791 | 0.792 | 0.793 | 0.794 | 0.795 | 0.796 | 0.797 |
| 32 | .788 | .789 | .790 | .791 | .792 | .793 | .795 | .796 | .797 | .798 |
| 34 | .789 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 |
| 36 | .790 | .791 | .792 | .793 | .794 | .795 | .796 | .797 | .798 | .799 |
| 38 | .791 | .792 | .793 | 7.94 | .795 | .796 | .797 | .798 | .799 | .800 |
| 40 | .7920 | .7930 | .7940 | .7450 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 |
| 42 | .7930 | .7940 | .7950 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 |
| 44 | .7935 | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 | .8025 |
| 46 | .7945 | .7955 | .7965 | .7975 | .7985 | .7995 | .8005 | .8015 | .8025 | .8035 |
| 48 | .7950 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 | .8030 | .8040 |
| 50 | .7960 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 | .8030 | .8040 | .8050 |
| 52 | .7970 | .7980 | .7990 | .8000 | .8010 | .8020 | .8030 | .8040 | .8050 | .8060 |
| 54 | .7975 | .7985 | .7995 | .8005 | .8015 | .8025 | .8035 | .8045 | .8055 | .8065 |
| 56 | .7985 | .7995 | .8005 | .8015 | .8025 | .8035 | .8045 | .8055 | .8065 | .8075 |
| 58 | .7995 | .8005 | .8015 | .8025 | .8035 | .8045 | .8055 | .8065 | .8075 | .8085 |
| 60 | .8000 | .8010 | .8020 | .8030 | .8040 | .8050 | .8060 | .8070 | .8080 | .8090 |
| 62 | .8005 | .8015 | .8025 | .8035 | .8045 | .8055 | .8065 | .8075 | .8085 | .8095 |
| 64 | .8015 | .8025 | .8035 | .8045 | .8055 | .8065 | .8075 | .8085 | .8095 | .8105 |
| 66 | .8025 | .8035 | .8045 | .8055 | .8065 | .8075 | .8085 | .8095 | .8105 | .8115 |
| 68 | .8030 | .8040 | .8050 | .8060 | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 |
| 70 | .8040 | .8050 | .8060 | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 | .8130 |
| 72 | .8045 | .8055 | .8065 | .8075 | .8085 | .8095 | .8105 | .8115 | .8125 | .8135 |
| 74 | .8055 | .8065 | .8075 | .8085 | .8095 | .8105 | .8115 | .8125 | .8135 | .8145 |
| 76 | .8065 | .8075 | .8085 | .8095 | .8105 | .8115 | .8120 | .8130 | .8140 | .8150 |
| 78 | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 | .8130 | .8140 | .8150 | .8160 |
| 80 | .808 | .809 | .810 | .811 | .812 | .813 | .813 | .814 | .815 | .816 |
| 82 | .808 | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 |
| 84 | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 |
| 86 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 |
| 88 | .811 | .812 | .813 | .814 | .815 | .816 | .816 | .817 | .818 | .819 |
| 90 | .812 | .813 | .814 | .815 | .816 | .817 | .817 | .818 | .819 | .820 |
| 92 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 | .821 |
| 94 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 | .821 | .822 |
| 96 | .814 | .815 | .816 | .817 | .818 | .819 | .819 | .820 | .821 | .822 |
| 98 | .815 | .816 | .817 | .818 | .819 | .820 | .820 | .821 | .822 | .823 |
| 100 | .815 | .816 | .817 | .818 | .819 | .820 | .821 | .822 | .823 | .824 |
| 102 | .816 | .817 | .818 | .819 | .820 | .821 | .822 | .823 | .824 | .825 |
| 104 | .817 | .818 | .819 | .820 | .821 | .822 | .822 | .823 | .824 | .825 |
| 106 | .817 | .818 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 |
| 108 | .818 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 |
| 110 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 |
| 112 | .820 | .821 | .822 | .823 | .824 | .825 | .825 | .826 | .827 | .828 |
| 114 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 |
| 116 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 |
| 118 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 | .831 |
| 120 | .823 | .824 | .825 | .826 | .827 | .828 | .828 | .829 | .830 | .831 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.810 | 0.811 | 0.812 | 0.813 | 0.814 | 0.815 | 0.816 | 0.817 | 0.818 | 0.819 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.798 | 0.799 | 0.800 | 0.801 | 0.802 | 0.803 | 0.804 | 0.805 | 0.806 | 0.807 |
| 32.......... | .799 | .800 | .801 | .802 | .803 | .804 | .805 | .806 | .807 | .808 |
| 34.......... | .799 | .800 | .801 | .802 | .803 | .804 | .806 | .807 | .808 | .809 |
| 36.......... | .800 | .801 | .802 | .803 | .804 | .805 | .807 | .808 | .809 | .810 |
| 38.......... | .801 | .802 | .803 | .804 | .805 | .806 | .808 | .809 | .810 | .811 |
| 40.......... | .8020 | .8030 | .8040 | .8050 | .8060 | .8070 | .8085 | .8095 | .8105 | .8115 |
| 42.......... | .8030 | .8040 | .8050 | .8060 | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 |
| 44.......... | .8035 | .8045 | .8055 | .8065 | .8075 | .8085 | .8100 | .8110 | .8120 | .8130 |
| 46.......... | .8045 | .8055 | .8065 | .8075 | .8085 | .8095 | .8105 | .8115 | .8125 | .8135 |
| 48.......... | .8050 | .8060 | .8070 | .8080 | .8090 | .8100 | .8115 | .8125 | .8135 | .8145 |
| 50.......... | .8060 | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 | .8130 | .8140 | .8150 |
| 52.......... | .8070 | .8080 | .8090 | .8100 | .8110 | .8120 | .8130 | .8140 | .8150 | .8160 |
| 54.......... | .8075 | .8085 | .8095 | .8105 | .8115 | .8125 | .8135 | .8145 | .8155 | .8165 |
| 56.......... | .8085 | .8095 | .8105 | .8115 | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 |
| 58.......... | .8095 | .8105 | .8115 | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 | .8185 |
| 60.......... | .8100 | .8110 | .8120 | .8130 | .8140 | .8150 | .8160 | .8170 | .8180 | .8190 |
| 62.......... | .8105 | .8115 | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 | .8185 | .8195 |
| 64.......... | .8115 | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 |
| 66.......... | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 | .8180 | .8190 | .8200 | .8210 |
| 68.......... | .8130 | .8140 | .8150 | .8160 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 |
| 70.......... | .8140 | .8150 | .8160 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 |
| 72.......... | .8145 | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 | .8215 | .8225 | .8235 |
| 74.......... | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 | .8215 | .8225 | .8235 | .8245 |
| 76.......... | .8160 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 | .8240 | .8250 |
| 78.......... | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 | .8240 | .8250 | .8260 |
| 80.......... | .817 | .818 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 |
| 82.......... | .818 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 |
| 84.......... | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 |
| 86.......... | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 |
| 88.......... | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 |
| 90.......... | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 |
| 92.......... | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 | .831 |
| 94.......... | .823 | .824 | .825 | .826 | .827 | .828 | .828 | .829 | .830 | .831 |
| 96.......... | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 | .831 | .832 |
| 98.......... | .824 | .825 | .826 | .827 | .828 | .829 | .830 | .831 | .832 | .833 |
| 100.......... | .825 | .826 | .827 | .828 | .829 | .830 | .831 | .832 | .833 | .834 |
| 102.......... | .826 | .827 | .828 | .829 | .830 | .831 | .831 | .832 | .833 | .834 |
| 104.......... | .826 | .827 | .828 | .829 | .830 | .831 | .832 | .833 | .834 | .835 |
| 106.......... | .827 | .828 | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 |
| 108.......... | .828 | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 |
| 110.......... | .829 | .830 | .831 | .832 | .833 | .834 | .834 | .835 | .836 | .837 |
| 112.......... | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 |
| 114.......... | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 |
| 116.......... | .831 | .832 | .833 | .834 | .835 | .836 | .836 | .837 | .838 | .839 |
| 118.......... | .832 | .833 | .834 | .835 | .836 | .837 | .837 | .838 | .839 | .840 |
| 120.......... | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.820 | 0.821 | 0.822 | 0.823 | 0.824 | 0.825 | 0.826 | 0.827 | 0.828 | 0.829 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.808 | 0.809 | 0.810 | 0.811 | 0.812 | 0.813 | 0.814 | 0.815 | 0.816 | 0.817 |
| 32 | .809 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 |
| 34 | .810 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 |
| 36 | .811 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 |
| 38 | .812 | .813 | .814 | .815 | .816 | .817 | .818 | .819 | .820 | .821 |
| 40 | .8125 | .8135 | .8145 | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 | .8215 |
| 42 | .8130 | .8140 | .8150 | .8160 | 8170 | .8180 | .8190 | .8200 | .8210 | .8220 |
| 44 | .8140 | .8150 | .8160 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 |
| 46 | .8145 | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 | .8215 | .8225 | .8235 |
| 48 | .8155 | .8165 | .8175 | .8185 | .8195 | .8205 | .8215 | .8225 | .8235 | .8240 |
| 50 | .8160 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 | .8240 | .8250 |
| 52 | .8170 | .8180 | .8190 | .8200 | .8210 | .8220 | .8230 | .8240 | .8250 | .8260 |
| 54 | .8175 | .8185 | .8195 | .8205 | .8215 | .8225 | .8240 | .8250 | .8260 | .8270 |
| 56 | .8185 | .8195 | .8205 | .8215 | .8225 | .8235 | .8245 | .8255 | .8265 | .8275 |
| 58 | .8195 | .8205 | .8215 | .8225 | .8235 | .8245 | .8255 | .8265 | .8275 | .8285 |
| 60 | .8200 | .8210 | .8220 | .8230 | .8240 | .8250 | .8260 | .8270 | .8280 | .8290 |
| 62 | .8205 | .8215 | .8225 | .8235 | .8245 | .8255 | .8265 | .8275 | .8285 | .8295 |
| 64 | .8215 | .8225 | .8235 | .8245 | .8255 | .8265 | .8275 | .8285 | .8295 | .8305 |
| 66 | .8220 | .8230 | .8240 | .8250 | .8260 | .8270 | .8280 | .8200 | .8300 | .8310 |
| 68 | .8230 | .8240 | .8250 | .8260 | .8270 | .8280 | .8290 | .8300 | .8310 | .8320 |
| 70 | .8240 | .8250 | .8260 | .8270 | .8280 | .8290 | .8300 | .8310 | .8320 | .8330 |
| 72 | .8245 | .8255 | .8265 | .8275 | .8285 | .8295 | .8305 | .8315 | .8325 | .8335 |
| 74 | .8255 | .8265 | .8275 | .8285 | .8295 | .8305 | .8315 | .8325 | .8335 | .8345 |
| 76 | .8260 | .8270 | .8280 | .8290 | .8300 | .8310 | .8320 | .8330 | .8340 | .8350 |
| 78 | .8270 | .8280 | .8290 | .8300 | .8310 | .8320 | .8330 | .8340 | .8350 | .8360 |
| 80 | .827 | .828 | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 |
| 82 | .828 | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 |
| 84 | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 |
| 86 | .830 | .831 | .832 | .833 | .834 | .835 | .835 | .836 | .837 | .838 |
| 88 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 |
| 90 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 |
| 92 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 |
| 94 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 |
| 96 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 | .842 |
| 98 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 | .842 | .843 |
| 100 | .835 | .836 | .837 | .838 | .839 | .840 | .840 | .841 | .842 | .843 |
| 102 | .835 | .836 | .837 | .838 | .839 | .840 | .841 | .842 | .843 | .844 |
| 104 | .836 | .837 | .838 | .839 | .840 | .841 | .842 | .843 | .844 | .845 |
| 106 | .837 | .838 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 |
| 108 | .838 | .839 | .840 | .841 | .842 | .843 | .843 | .844 | .845 | .846 |
| 110 | .838 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 |
| 112 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 |
| 114 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 |
| 116 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 |
| 118 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 |
| 120 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.830 | 0.831 | 0.832 | 0.833 | 0.834 | 0.835 | 0.836 | 0.837 | 0.838 | 0.839 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.818 | 0.819 | 0.820 | 0.821 | 0.822 | 0.823 | 0.824 | 0.825 | 0.826 | 0.827 |
| 32 | .819 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 |
| 34 | .820 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 |
| 36 | .821 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 |
| 38 | .822 | .823 | .824 | .825 | .826 | .827 | .828 | .829 | .830 | .831 |
| 40 | .8225 | .8235 | .8245 | .8255 | .8265 | .8275 | .8285 | .8295 | .8305 | .8315 |
| 42 | .8230 | .8240 | .8250 | .8260 | .8270 | .8280 | .8295 | .8305 | .8315 | .8325 |
| 44 | .8240 | .8250 | .8260 | .8270 | .8280 | .8290 | .8300 | .8310 | .8320 | .8330 |
| 46 | .8245 | .8255 | .8265 | .8275 | .8285 | .8295 | .8305 | .8315 | .8325 | .8335 |
| 48 | .8255 | .8265 | .8275 | .8285 | .8290 | .8305 | .8315 | .8325 | .8335 | .8345 |
| 50 | .8260 | .8270 | .8280 | .8290 | .8300 | .8310 | .8325 | .8335 | .8345 | .8355 |
| 52 | .8270 | .8280 | .8290 | .8300 | 8310 | .8320 | .8330 | .8340 | .8350 | .8360 |
| 54 | .8280 | .8290 | .8300 | .8310 | 8320 | .8330 | .8340 | .8350 | .8360 | .8370 |
| 56 | .8285 | .8295 | .8305 | .8315 | .8325 | .8335 | .8345 | .8355 | .8365 | .8375 |
| 58 | .8295 | .8305 | .8315 | .8325 | .8335 | .8345 | .8355 | .8365 | .8375 | .8385 |
| 60 | .8300 | .8310 | .8320 | .8330 | .8340 | .8350 | .8360 | .8370 | .8380 | .8390 |
| 62 | .8305 | .8315 | .8325 | .8335 | .8345 | .8355 | .8365 | .8375 | .8385 | .8390 |
| 64 | .8315 | .8325 | .8335 | .8345 | .8355 | .8365 | .8375 | .8385 | .8395 | .8400 |
| 66 | .8320 | .8330 | .8340 | .8350 | .8360 | .8370 | .8380 | .8390 | .8400 | .8410 |
| 68 | .8330 | .8340 | .8350 | .8360 | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 |
| 70 | .8340 | .8350 | .8360 | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 |
| 72 | .8345 | .8355 | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 | .8425 | .8435 |
| 74 | .8355 | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 | .8425 | .8435 | .8445 |
| 76 | .8360 | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 | .8440 | .8450 |
| 78 | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 | .8440 | .8450 | .8460 |
| 80 | .837 | .838 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 |
| 82 | .838 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 |
| 84 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 |
| 86 | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 |
| 88 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 |
| 90 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 |
| 92 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 |
| 94 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 |
| 96 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 | .852 |
| 98 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 | .852 | .853 |
| 100 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 | .852 | .853 |
| 102 | .845 | .846 | .847 | .848 | .849 | .850 | .851 | .852 | .853 | .854 |
| 104 | .846 | .847 | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 |
| 106 | .847 | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 |
| 108 | .847 | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 |
| 110 | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 |
| 112 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 |
| 114 | .850 | .851 | .852 | .853 | .854 | .855 | .855 | .856 | .857 | .858 |
| 116 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 |
| 118 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 |
| 120 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.840 | 0.841 | 0.842 | 0.843 | 0.844 | 0.845 | 0.846 | 0.847 | 0.848 | 0.849 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.828 | 0.829 | 0.830 | 0.831 | 0.832 | 0.833 | 0.835 | 0.836 | 0.837 | 0.838 |
| 32.......... | .829 | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 |
| 34.......... | .830 | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 |
| 36.......... | .831 | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 |
| 38.......... | .832 | .833 | .834 | .835 | .836 | .837 | .838 | .839 | .840 | .841 |
| 40.......... | .8325 | .8335 | .8345 | .8355 | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 |
| 42.......... | .8335 | .8345 | .8355 | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 | .8425 |
| 44.......... | .8340 | .8350 | .8360 | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 |
| 46.......... | .8345 | .8355 | .8365 | .8375 | .8385 | .8395 | .8410 | .8420 | .8430 | .8440 |
| 48.......... | .8355 | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 | .8425 | .8435 | .8445 |
| 50.......... | .8365 | .8375 | .8385 | .8395 | .8405 | .8415 | .8425 | .8435 | .8445 | .8455 |
| 52.......... | .8370 | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 | .8440 | .8450 | .8460 |
| 54.......... | .8380 | .8390 | .8400 | .8410 | .8420 | .8430 | .8440 | .8450 | .8460 | .8470 |
| 56.......... | .8385 | .8395 | .8405 | .8415 | .8425 | .8435 | .8445 | .8455 | .8465 | .8475 |
| 58.......... | .8395 | .8405 | .8415 | .8425 | .8435 | .8445 | .8455 | .8465 | .8475 | .8485 |
| 60.......... | .8400 | .8410 | .8420 | .8430 | .8440 | .8450 | .8460 | .8470 | .8480 | .8490 |
| 62.......... | .8405 | .8415 | .8425 | .8435 | .8445 | .8455 | .8465 | .8475 | .8485 | .8495 |
| 64.......... | .8415 | .8425 | .8435 | .8445 | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 |
| 66.......... | .8420 | .8430 | .8440 | .8450 | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 |
| 68.......... | .8430 | .8440 | .8450 | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 |
| 70.......... | .8440 | .8450 | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 |
| 72.......... | .8445 | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 | .8515 | .8525 | .8535 |
| 74.......... | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 | .8510 | .8520 | .8530 | .8540 |
| 76.......... | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 | .8540 | .8550 |
| 78.......... | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8525 | .8535 | .8545 | .8555 |
| 80.......... | .847 | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 |
| 82.......... | .848 | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 |
| 84.......... | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 |
| 86.......... | .849 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 |
| 88.......... | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 |
| 90.......... | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 |
| 92.......... | .852 | .853 | .854 | .855 | .856 | .857 | .857 | .858 | .859 | .860 |
| 94.......... | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 |
| 96.......... | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 | .862 |
| 98.......... | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 | .862 | .863 |
| 100.......... | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 | .862 | .863 |
| 102.......... | .855 | .856 | .857 | .858 | .859 | .860 | .861 | .862 | .863 | .864 |
| 104.......... | .856 | .857 | .858 | .859 | .860 | .861 | .862 | .863 | .864 | .865 |
| 106.......... | .857 | .858 | .859 | .860 | .861 | .862 | .862 | .863 | .864 | .865 |
| 108.......... | .857 | .858 | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 |
| 110.......... | .858 | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 |
| 112.......... | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 |
| 114.......... | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 |
| 116.......... | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 |
| 118.......... | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 |
| 120.......... | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 | .871 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.850 | 0.851 | 0.852 | 0.853 | 0.854 | 0.855 | 0.856 | 0.857 | 0.858 | 0.859 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.839 | 0.840 | 0.841 | 0.842 | 0.843 | 0.844 | 0.845 | 0.846 | 0.847 | 0.848 |
| 32.......... | .839 | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 |
| 34.......... | .840 | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 |
| 36.......... | .841 | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 |
| 38.......... | .842 | .843 | .844 | .845 | .846 | .847 | .848 | .849 | .850 | .851 |
| 40.......... | .8425 | .8435 | .8445 | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 | .8515 |
| 42.......... | .8435 | .8445 | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 | .8515 | .8525 |
| 44.......... | .8440 | .8450 | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 |
| 46.......... | .8450 | .8460 | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 | .8540 |
| 48.......... | .8455 | .8465 | .8475 | .8485 | .8495 | .8505 | .8515 | .8525 | .8535 | .8545 |
| 50.......... | .8465 | .8475 | .8485 | .8495 | .8505 | .8515 | .8525 | .8535 | .8545 | .8555 |
| 52.......... | .8470 | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 | .8540 | .8550 | .8560 |
| 54.......... | .8480 | .8490 | .8500 | .8510 | .8520 | .8530 | .8540 | .8550 | .8560 | .8570 |
| 56.......... | .8485 | .8495 | .8505 | .8515 | .8525 | .8535 | .8545 | .8555 | .8565 | .8575 |
| 58.......... | .8495 | .8505 | .8515 | .8525 | .8535 | .8545 | .8555 | .8565 | .8575 | .8585 |
| 60.......... | .8500 | .8510 | .8520 | .8530 | .8540 | .8550 | .8560 | .8570 | .8580 | .8590 |
| 62.......... | .8505 | .8515 | .8525 | .8535 | .8545 | .8555 | .8565 | .8575 | .8585 | .8595 |
| 64.......... | .8515 | .8525 | .8535 | .8545 | .8555 | .8565 | .8575 | .8585 | .8595 | .8605 |
| 66.......... | .8520 | .8530 | .8540 | .8550 | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 |
| 68.......... | .8530 | .8540 | .8550 | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 |
| 70.......... | .8540 | .8550 | .8560 | .8570 | .8580 | .8590 | .8595 | .8605 | .8615 | .8625 |
| 72.......... | .8545 | .8555 | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 | .8625 | .8635 |
| 74.......... | .8550 | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 | .8640 |
| 76.......... | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 | .8640 | .8650 |
| 78.......... | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 | .8625 | .8635 | .8645 | .8655 |
| 80.......... | .857 | .858 | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 |
| 82.......... | .858 | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 |
| 84.......... | .859 | .860 | .861 | .862 | .863 | .864 | .864 | .865 | .866 | .867 |
| 86.......... | .859 | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 |
| 88.......... | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 |
| 90.......... | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 |
| 92.......... | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 |
| 94.......... | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 | .871 |
| 96.......... | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 | .871 | .872 |
| 98.......... | .864 | .865 | .866 | .867 | .868 | .869 | .869 | .870 | .871 | .872 |
| 100.......... | .864 | .865 | .866 | .867 | .868 | .869 | .870 | .871 | .872 | .873 |
| 102.......... | .865 | .866 | .867 | .868 | .869 | .870 | .871 | .872 | .873 | .874 |
| 104.......... | .866 | .867 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 |
| 106.......... | .866 | .867 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 |
| 108.......... | .867 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 |
| 110.......... | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 |
| 112.......... | .869 | .870 | .871 | .872 | .873 | .874 | .874 | .875 | .876 | .877 |
| 114.......... | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 |
| 116.......... | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 |
| 118.......... | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 |
| 120.......... | .872 | .873 | .874 | .875 | .876 | .877 | .877 | .878 | .879 | .880 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.860 | 0.861 | 0.862 | 0.863 | 0.864 | 0.865 | 0.866 | 0.867 | 0.868 | 0.869 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.849 | 0.850 | 0.851 | 0.852 | 0.853 | 0.854 | 0.855 | 0.856 | 0.857 | 0.858 |
| 32 | .849 | .850 | .851 | .852 | .853 | .854 | .856 | .857 | .858 | .859 |
| 34 | .850 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 |
| 36 | .851 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 |
| 38 | .852 | .853 | .854 | .855 | .856 | .857 | .858 | .859 | .860 | .861 |
| 40 | .8525 | .8535 | .8545 | .8555 | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 |
| 42 | .8535 | .8545 | .8555 | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 | .8625 |
| 44 | .8540 | .8550 | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 |
| 46 | .8550 | .8560 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 | .8640 |
| 48 | .8555 | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 | .8625 | .8635 | .8645 |
| 50 | .8565 | .8575 | .8585 | .8595 | .8605 | .8615 | .8625 | .8635 | .8645 | .8655 |
| 52 | .8570 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 | .8640 | .8650 | .8660 |
| 54 | .8580 | .8590 | .8600 | .8610 | .8620 | .8630 | .8640 | .8650 | .8660 | .8670 |
| 56 | .8585 | .8595 | .8605 | .8615 | .8625 | .8635 | .8645 | .8655 | .8665 | .8675 |
| 58 | .8595 | .8605 | .8615 | .8625 | .8635 | .8645 | .8655 | .8665 | .8675 | .8685 |
| 60 | .8600 | .8610 | .8620 | .8630 | .8640 | .8650 | .8660 | .8670 | .8680 | .8690 |
| 62 | .8605 | .8615 | .8625 | .8635 | .8645 | .8655 | .8665 | .8675 | .8685 | .8695 |
| 64 | .8615 | .8625 | .8635 | .8645 | .8655 | .8665 | .8675 | .8685 | .8695 | .8705 |
| 66 | .8620 | .8630 | .8640 | .8650 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 |
| 68 | .8630 | .8640 | .8650 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 |
| 70 | .8635 | .8645 | .8655 | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 |
| 72 | .8645 | .8655 | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 | .8735 |
| 74 | .8650 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 | .8740 |
| 76 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 | .8740 | .8750 |
| 78 | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 | .8735 | .8745 | .8755 |
| 80 | .867 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 |
| 82 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 |
| 84 | .868 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 |
| 86 | .869 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 |
| 88 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 |
| 90 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 |
| 92 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 |
| 94 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 | .881 |
| 96 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 | .881 | .882 |
| 98 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 | .881 | .882 |
| 100 | .874 | .875 | .876 | .877 | .878 | .879 | .880 | .881 | .882 | .883 |
| 102 | .875 | .876 | .877 | .878 | .879 | .880 | .881 | .882 | .883 | .884 |
| 104 | .876 | .877 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 |
| 106 | .876 | .877 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 |
| 108 | .877 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 |
| 110 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 |
| 112 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 |
| 114 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 |
| 116 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 |
| 118 | .881 | .882 | .883 | .884 | .885 | .886 | .886 | .887 | .888 | .889 |
| 120 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.870 | 0.871 | 0.872 | 0.873 | 0.874 | 0.875 | 0.876 | 0.877 | 0.878 | 0.879 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.859 | 0.860 | 0.861 | 0.862 | 0.863 | 0.864 | 0.865 | 0.866 | 0.867 | 0.868 |
| 32.......... | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 |
| 34.......... | .860 | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 |
| 36.......... | .861 | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 |
| 38.......... | .862 | .863 | .864 | .865 | .866 | .867 | .868 | .869 | .870 | .871 |
| 40.......... | .8625 | .8635 | .8645 | .8655 | .8665 | .8675 | .8690 | .8700 | .8710 | .8720 |
| 42.......... | .8635 | .8645 | .8655 | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 |
| 44.......... | .8640 | .8650 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 |
| 46.......... | .8650 | .8660 | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 | .8740 |
| 48.......... | .8655 | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 | .8735 | .8745 |
| 50.......... | .8665 | .8675 | .8685 | .8695 | .8705 | .8715 | .8725 | .8735 | .8745 | .8755 |
| 52.......... | .8670 | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 | .8740 | .8750 | .8760 |
| 54.......... | .8680 | .8690 | .8700 | .8710 | .8720 | .8730 | .8740 | .8750 | .8760 | .8770 |
| 56.......... | .8685 | .8695 | .8705 | .8715 | .8725 | .8735 | .8745 | .8755 | .8765 | .8775 |
| 58.......... | .8695 | .8705 | .8715 | .8725 | .8735 | .8745 | .8755 | .8765 | .8775 | .8785 |
| 60.......... | .8700 | .8710 | .8720 | .8730 | .8740 | .8750 | .8760 | .8770 | .8780 | .8790 |
| 62.......... | .8705 | .8715 | .8725 | .8735 | .8745 | .8755 | .8765 | .8775 | .8785 | .8795 |
| 64.......... | .8715 | .8725 | .8735 | .8745 | .8755 | .8765 | .8775 | .8785 | .8795 | .8805 |
| 66.......... | .8720 | .8730 | .8740 | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 |
| 68.......... | .8730 | .8740 | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 |
| 70.......... | .8735 | .8745 | .8755 | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 |
| 72.......... | .8745 | .8755 | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 | .8835 |
| 74.......... | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 | .8840 |
| 76.......... | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 | .8840 | .8850 |
| 78.......... | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 | .8835 | .8845 | .8855 |
| 80.......... | .877 | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 |
| 82.......... | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 |
| 84.......... | .878 | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 |
| 86.......... | .879 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 |
| 88.......... | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 |
| 90.......... | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 |
| 92.......... | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 |
| 94.......... | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 | .891 |
| 96.......... | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 | .891 | .892 |
| 98.......... | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 | .891 | .892 |
| 100.......... | .884 | .885 | .886 | .887 | .888 | .889 | .890 | .891 | .892 | .893 |
| 102.......... | .885 | .886 | .887 | .888 | .889 | .890 | .891 | .892 | .893 | .894 |
| 104.......... | .886 | .887 | .888 | .889 | .890 | .891 | .891 | .892 | .893 | .894 |
| 106.......... | .886 | .887 | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 |
| 108.......... | .887 | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 |
| 110.......... | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 |
| 112.......... | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 |
| 114.......... | .889 | .890 | .891 | .892 | .803 | .894 | .895 | .896 | .897 | .898 |
| 116.......... | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 |
| 118.......... | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 |
| 120.......... | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.880 | 0.881 | 0.882 | 0.883 | 0.884 | 0.885 | 0.886 | 0.887 | 0.888 | 0.889 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.869 | 0.870 | 0.871 | 0.872 | 0.873 | 0.874 | 0.875 | 0.876 | 0.877 | 0.878 |
| 32 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 |
| 34 | .870 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 |
| 36 | .871 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 |
| 38 | .872 | .873 | .874 | .875 | .876 | .877 | .878 | .879 | .880 | .881 |
| 40 | .8730 | .8740 | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 |
| 42 | .8735 | .8745 | .8755 | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 |
| 44 | .8740 | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 |
| 46 | .8750 | .8760 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 | .8840 |
| 48 | .8755 | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 | .8835 | .8845 |
| 50 | .8765 | .8775 | .8785 | .8795 | .8805 | .8815 | .8825 | .8835 | .8845 | .8855 |
| 52 | .8770 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 | .8840 | .8850 | .8860 |
| 54 | .8780 | .8790 | .8800 | .8810 | .8820 | .8830 | .8840 | .8850 | .8860 | .8870 |
| 56 | .8785 | .8795 | .8805 | .8815 | .8825 | .8835 | .8845 | .8855 | .8865 | .8875 |
| 58 | .8795 | .8805 | .8815 | .8825 | .8835 | .8845 | .8855 | .8865 | .8875 | .8885 |
| 60 | .8800 | .8810 | .8820 | .8830 | .8840 | .8850 | .8860 | .8870 | .8880 | .8890 |
| 62 | .8805 | .8815 | .8825 | .8835 | .8845 | .8855 | .8865 | .8875 | .8885 | .8895 |
| 64 | .8815 | .8825 | .8835 | .8845 | .8855 | .8865 | .8875 | .8885 | .8895 | .8905 |
| 66 | .8820 | .8830 | .8840 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 |
| 68 | .8830 | .8840 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 |
| 70 | .8835 | .8845 | .8855 | .8865 | .8875 | .8885 | .8895 | .8905 | .8915 | .8925 |
| 72 | .8845 | .8855 | .8865 | .8875 | .8885 | .8895 | .8900 | .8910 | .8920 | .8930 |
| 74 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 | .8930 | .8940 |
| 76 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8915 | .8925 | .8935 | .8945 |
| 78 | .8865 | .8875 | .8885 | .8895 | .8905 | .8915 | .8925 | .8935 | .8945 | .8955 |
| 80 | .887 | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 |
| 82 | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 |
| 84 | .888 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 |
| 86 | .889 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 |
| 88 | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 |
| 90 | .891 | .892 | .893 | .894 | .895 | .896 | .896 | .897 | .898 | .899 |
| 92 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 |
| 94 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 | .901 |
| 96 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 | .901 | .902 |
| 98 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 | .901 | .902 |
| 100 | .894 | .895 | .896 | .897 | .898 | .899 | .900 | .901 | .902 | .903 |
| 102 | .895 | .896 | .897 | .898 | .899 | .900 | .901 | .902 | .903 | .904 |
| 104 | .895 | .896 | .897 | .898 | .899 | .900 | .901 | .902 | .903 | .904 |
| 106 | .896 | .897 | .898 | .899 | .900 | .901 | .902 | .903 | .904 | .905 |
| 108 | .897 | .898 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 |
| 110 | .898 | .899 | .900 | .901 | .902 | .903 | .903 | .904 | .905 | .906 |
| 112 | .898 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 |
| 114 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 |
| 116 | .900 | .901 | .902 | .903 | .904 | .905 | .905 | .906 | .907 | .908 |
| 118 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 |
| 120 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.890 | 0.891 | 0.892 | 0.893 | 0.894 | 0.895 | 0.896 | 0.897 | 0.898 | 0.899 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.879 | 0.880 | 0.881 | 0.882 | 0.883 | 0.884 | 0.885 | 0.886 | 0.887 | 0.888 |
| 32 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 |
| 34 | .880 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 |
| 36 | .881 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 |
| 38 | .882 | .883 | .884 | .885 | .886 | .887 | .888 | .889 | .890 | .891 |
| 40 | .8830 | .8840 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 |
| 42 | .8840 | .8850 | .8860 | .8870 | .8880 | .8885 | .8895 | .8905 | .8915 | .8925 |
| 44 | .8840 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 | .8930 |
| 46 | .8850 | .8860 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 | .8930 | .8940 |
| 48 | .8855 | .8865 | .8875 | .8885 | .8895 | .8905 | .8915 | .8925 | .8935 | .8945 |
| 50 | .8865 | .8875 | .8885 | .8895 | .8905 | .8915 | .8925 | .8935 | .8945 | .8955 |
| 52 | .8870 | .8880 | .8890 | .8900 | .8910 | .8920 | .8930 | .8940 | .8950 | .8960 |
| 54 | .8880 | .8890 | .8900 | .8910 | .8920 | .8930 | .8940 | .8950 | .8960 | .8970 |
| 56 | .8885 | .8895 | .8905 | .8915 | .8925 | .8935 | .8945 | .8955 | .8965 | .8975 |
| 58 | .8895 | .8905 | .8915 | .8925 | .8935 | .8945 | .8955 | .8965 | .8975 | .8985 |
| 60 | .8900 | .8910 | .8920 | .8930 | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 |
| 62 | .8905 | .8915 | .8925 | .8935 | .8945 | .8955 | .8965 | .8975 | .8985 | .8995 |
| 64 | .8915 | .8925 | .8935 | .8945 | .8955 | .8965 | .8975 | .8985 | .8995 | .9005 |
| 66 | .8920 | .8930 | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 |
| 68 | .8930 | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 |
| 70 | .8935 | .8945 | .8955 | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 |
| 72 | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 | .9030 |
| 74 | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 | .9030 | .9040 |
| 76 | .8955 | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 |
| 78 | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 | .9055 |
| 80 | .897 | .898 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 |
| 82 | .898 | .899 | .900 | .901 | .902 | .903 | .903 | .904 | .905 | .906 |
| 84 | .898 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 |
| 86 | .899 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 |
| 88 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 |
| 90 | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 |
| 92 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 |
| 94 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 | .911 |
| 96 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 | .911 | .912 |
| 98 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 | .911 | .912 |
| 100 | .904 | .905 | .906 | .907 | .908 | .909 | .910 | .911 | .912 | .913 |
| 102 | .905 | .906 | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 |
| 104 | .905 | .906 | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 |
| 106 | .906 | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 |
| 108 | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 |
| 110 | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 |
| 112 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 |
| 114 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 |
| 116 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 |
| 118 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 |
| 120 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.900 | 0.901 | 0.902 | 0.903 | 0.904 | 0.905 | 0.906 | 0.907 | 0.908 | 0.909 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.889 | 0.890 | 0.891 | 0.892 | 0.893 | 0.894 | 0.895 | 0.896 | 0.897 | 0.898 |
| 32.......... | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 |
| 34.......... | .890 | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 |
| 36.......... | .891 | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 |
| 38.......... | .892 | .893 | .894 | .895 | .896 | .897 | .898 | .899 | .900 | .901 |
| 40.......... | .8930 | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 |
| 42.......... | .8935 | .8945 | .8955 | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 |
| 44.......... | .8940 | .8950 | .8960 | .8970 | .8980 | .8990 | .9005 | .9015 | .9025 | .9035 |
| 46.......... | .8950 | .8960 | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 | .9030 | .9040 |
| 48.......... | .8955 | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 |
| 50.......... | .8965 | .8975 | .8985 | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 | .9055 |
| 52.......... | .8970 | .8980 | .8990 | .9000 | .9010 | .9020 | .9030 | .9040 | .9050 | .9060 |
| 54.......... | .8980 | .8990 | .9000 | .9010 | .9020 | .9030 | .9040 | .9050 | .9060 | .9070 |
| 56.......... | .8985 | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 | .9055 | .9065 | .9075 |
| 58.......... | .8995 | .9005 | .9015 | .9025 | .9035 | .9045 | .9055 | .9065 | .9075 | .9085 |
| 60.......... | .9000 | .9010 | .9020 | .9030 | .9040 | .9050 | .9060 | .9070 | .9080 | .9090 |
| 62.......... | .9005 | .9015 | .9025 | .9035 | .9045 | .9055 | .9065 | .9075 | .9085 | .9095 |
| 64.......... | .9015 | .9025 | .9035 | .9045 | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 |
| 66.......... | .9020 | .9030 | .9040 | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 |
| 68.......... | .9030 | .9040 | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 |
| 70.......... | .9035 | .9045 | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 |
| 72.......... | .9040 | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 | .9130 |
| 74.......... | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 | .9130 | .9140 |
| 76.......... | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 |
| 78.......... | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 | .9155 |
| 80.......... | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 |
| 82.......... | .907 | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 |
| 84.......... | .908 | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 |
| 86.......... | .909 | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 |
| 88.......... | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 |
| 90.......... | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 |
| 92.......... | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 |
| 94.......... | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 | .921 |
| 96.......... | .913 | .914 | .915 | .916 | .917 | .918 | .918 | .919 | .920 | .921 |
| 98.......... | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 | .921 | .922 |
| 100.......... | .914 | .915 | .916 | .917 | .918 | .919 | .920 | .921 | .922 | .923 |
| 102.......... | .915 | .916 | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 |
| 104.......... | .915 | .916 | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 |
| 106.......... | .916 | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 |
| 108.......... | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 |
| 110.......... | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 |
| 112.......... | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 |
| 114.......... | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 |
| 116.......... | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 |
| 118.......... | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 |
| 120.......... | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.910 | 0.911 | 0.912 | 0.913 | 0.914 | 0.915 | 0.916 | 0.917 | 0.918 | 0.919 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.899 | 0.900 | 0.901 | 0.902 | 0.903 | 0.904 | 0.905 | 0.906 | 0.907 | 0.908 |
| 32.......... | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 |
| 34.......... | .900 | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 |
| 36.......... | .901 | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 |
| 38.......... | .902 | .903 | .904 | .905 | .906 | .907 | .908 | .909 | .910 | .911 |
| 40.......... | .9030 | .9040 | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 |
| 42.......... | .9035 | .9045 | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 |
| 44.......... | .9045 | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 |
| 46.......... | .9050 | .9060 | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 | .9130 | .9140 |
| 48.......... | .9055 | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 |
| 50.......... | .9065 | .9075 | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 | .9155 |
| 52.......... | .9070 | .9080 | .9090 | .9100 | .9110 | .9120 | .9130 | .9140 | .9150 | .9160 |
| 54.......... | .9080 | .9090 | .9100 | .9110 | .9120 | .9130 | .9140 | .9150 | .9160 | .9170 |
| 56.......... | .9085 | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 | .9155 | .9165 | .9175 |
| 58.......... | .9095 | .9105 | .9115 | .9125 | .9135 | .9145 | .9155 | .9165 | .9175 | .9185 |
| 60.......... | .9100 | .9110 | .9120 | .9130 | .9140 | .9150 | .9160 | .9170 | .9180 | .9190 |
| 62.......... | .9105 | .9115 | .9125 | .9135 | .9145 | .9155 | .9165 | .9175 | .9185 | .9195 |
| 64.......... | .9115 | .9125 | .9135 | .9145 | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 |
| 66.......... | .9120 | .9130 | .9140 | .9150 | .9160 | .9170 | .9180 | .9190 | .9200 | .9210 |
| 68.......... | .9130 | .9140 | .9150 | .9160 | .9170 | .9180 | .9190 | .9200 | .9210 | .9220 |
| 70.......... | .9135 | .9145 | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 |
| 72.......... | .9140 | .9150 | .9160 | .9170 | .9180 | .9190 | .9200 | .9210 | .9220 | .9230 |
| 74.......... | .9150 | .9160 | .9170 | .9180 | .9190 | .9200 | .9210 | .9220 | .9230 | .9240 |
| 76.......... | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 |
| 78.......... | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 | .9255 |
| 80.......... | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 |
| 82.......... | .917 | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 |
| 84.......... | .918 | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 |
| 86.......... | .919 | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 |
| 88.......... | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 |
| 90.......... | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 |
| 92.......... | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 |
| 94.......... | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 | .931 |
| 96.......... | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 | .931 |
| 98.......... | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 | .931 | .932 |
| 100.......... | .924 | .925 | .926 | .927 | .928 | .929 | .930 | .931 | .932 | .933 |
| 102.......... | .925 | .926 | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 |
| 104.......... | .925 | .926 | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 |
| 106.......... | .926 | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 |
| 108.......... | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 |
| 110.......... | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 |
| 112.......... | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 |
| 114.......... | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 |
| 116.......... | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 |
| 118.......... | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 |
| 120.......... | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.920 | 0.921 | 0.922 | 0.923 | 0.924 | 0.925 | 0.926 | 0.927 | 0.928 | 0.929 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.909 | 0.910 | 0.911 | 0.912 | 0.913 | 0.914 | 0.915 | 0.916 | 0.917 | 0.918 |
| 32.......... | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 |
| 34.......... | .910 | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 |
| 36.......... | .911 | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 |
| 38.......... | .912 | .913 | .914 | .915 | .916 | .917 | .918 | .919 | .920 | .921 |
| 40.......... | .9130 | .9140 | .9150 | .9160 | .9170 | .9180 | .9190 | .9[illegible]00 | .9210 | .9220 |
| 42.......... | .9135 | .9145 | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 |
| 44.......... | .9145 | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 |
| 46.......... | .9150 | .9160 | .9170 | .9180 | .9190 | .9200 | .9210 | .9220 | .9230 | .9240 |
| 48.......... | .9155 | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 |
| 50.......... | .9165 | .9175 | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 | .9255 |
| 52.......... | .9170 | .9180 | .9190 | .9200 | .9210 | .9220 | .9230 | .9240 | .9250 | .9260 |
| 54.......... | .9180 | .9190 | .9200 | .9210 | .92[illegible]0 | .9230 | .9240 | .9250 | .9260 | .9270 |
| 56.......... | .9185 | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 | .9255 | .9265 | .9275 |
| 58.......... | .9195 | .9205 | .9215 | .9225 | .9235 | .9245 | .9255 | .9265 | .9275 | .9285 |
| 60.......... | .9200 | .9210 | .9220 | .9230 | .9240 | .9250 | .9260 | .9270 | .9280 | .9290 |
| 62.......... | .9205 | .9215 | .9225 | .9235 | .9245 | .9255 | .92[illegible]5 | .9275 | .9285 | .9295 |
| 64.......... | .9215 | .9225 | .9235 | .9245 | .9255 | .9265 | .9275 | .9285 | .9295 | .9305 |
| 66.......... | .9220 | 92[illegible]0 | .9240 | .9250 | .9260 | .9270 | .9280 | .9[illegible]90 | .9300 | .9310 |
| 68.......... | .9230 | .9240 | .9250 | .9260 | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 |
| 70.......... | .9235 | .9245 | .9255 | .9265 | .9275 | .9285 | .9295 | .9305 | .9315 | .9325 |
| 72.......... | .9240 | .9250 | .9260 | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 | .9330 |
| 74.......... | .9250 | .9260 | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 | .9330 | .9340 |
| 76.......... | .9255 | .9265 | .9275 | .9285 | .9[illegible]95 | .9305 | .9315 | .9325 | .9335 | .9345 |
| 78.......... | .9265 | .9275 | .9285 | .9295 | .9305 | .9315 | .9325 | .9335 | .9345 | .9355 |
| 80.......... | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 |
| 82.......... | .927 | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 |
| 84.......... | .928 | .929 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 |
| 86.......... | .929 | .930 | .931 | .932 | .033 | .934 | .935 | .936 | .937 | .938 |
| 88.......... | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 |
| 90.......... | .930 | .931 | .932 | .933 | .9[illegible]4 | .935 | .936 | .937 | .938 | .939 |
| 92.......... | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 |
| 94.......... | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 | .941 |
| 96.......... | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 | .941 |
| 98.......... | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 | .941 | .942 |
| 100.......... | .934 | .935 | .936 | .937 | .938 | .939 | .940 | .941 | .942 | .943 |
| 102.......... | .935 | .936 | .937 | .938 | .939 | .940 | .940 | .941 | .942 | .943 |
| 104.......... | .935 | .936 | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 |
| 106.......... | .936 | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 |
| 108.......... | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 |
| 110.......... | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 |
| 112.......... | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 |
| 114.......... | .939 | .940 | .941 | .942 | .943 | .944 | 9.45 | 9.46 | .947 | .948 |
| 116.......... | .939 | .940 | .941 | .942 | .943 | .944 | 9.45 | 9.46 | .947 | .948 |
| 118.......... | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 |
| 120.......... | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.930 | 0.931 | 0.932 | 0.933 | 0.934 | 0.935 | 0.936 | 0.937 | 0.938 | 0.939 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.919 | 0.920 | 0.921 | 0.922 | 0.923 | 0.924 | 0.925 | 0.926 | 0.927 | 0.928 |
| 32.......... | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 |
| 34.......... | .920 | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 |
| 36.......... | .921 | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 |
| 38.......... | .922 | .923 | .924 | .925 | .926 | .927 | .928 | .929 | .930 | .931 |
| 40.......... | .9230 | .9240 | .9250 | .9260 | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 |
| 42.......... | .9235 | .9245 | .9255 | .9265 | .9275 | .9285 | .9295 | .9305 | .9315 | .9325 |
| 44.......... | .9245 | .9255 | .9265 | .9275 | .9285 | .9295 | .9305 | .9315 | .9325 | .9335 |
| 46.......... | .9250 | .9260 | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 | .9330 | .9340 |
| 48.......... | .9255 | .9265 | .9275 | .9285 | .9295 | .9305 | .9320 | .9330 | .9340 | .9350 |
| 50.......... | .9265 | .9275 | .9285 | .9295 | .9305 | .9315 | .9325 | .9335 | .9345 | .9355 |
| 52.......... | .9270 | .9280 | .9290 | .9300 | .9310 | .9320 | .9330 | .9340 | .9350 | .9360 |
| 54.......... | .9280 | .9290 | .9300 | .9310 | .9320 | .9330 | .9340 | .9350 | .9360 | .9370 |
| 56.......... | .9285 | .9295 | .9305 | .9315 | .9325 | .9335 | .9345 | .9355 | .9365 | .9375 |
| 58.......... | .9295 | .9305 | .9315 | .9325 | .9335 | .9345 | .9355 | .9365 | .9375 | .9385 |
| 60.......... | .9300 | .9310 | .9320 | .9330 | .9340 | .9350 | .9360 | .9370 | .9380 | .9390 |
| 62.......... | .9305 | .9315 | .9325 | .9335 | .9345 | .9355 | .9365 | .9375 | .9385 | .9395 |
| 64.......... | .9315 | .9325 | .9335 | .9345 | .9355 | .9365 | .9375 | .9385 | .9395 | .9405 |
| 66.......... | .9320 | .9330 | .9340 | .9350 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 |
| 68.......... | .9330 | .9340 | .9350 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 |
| 70.......... | .9335 | .9345 | .9355 | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 |
| 72.......... | .9340 | .9350 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 |
| 74.......... | .9350 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 | .9440 |
| 76.......... | .9355 | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 | .9435 | .9445 |
| 78.......... | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 | .9435 | .9445 | .9455 |
| 80.......... | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 |
| 82.......... | .937 | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 |
| 84.......... | .938 | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 |
| 86.......... | .939 | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 |
| 88.......... | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 |
| 90.......... | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 |
| 92.......... | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 |
| 94.......... | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 | |
| 96.......... | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | | |
| 98.......... | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 | | |
| 100.......... | .944 | .945 | .946 | .947 | .948 | .949 | .950 | | | |
| 102.......... | .944 | .945 | .946 | .947 | .948 | .950 | | | | |
| 104.......... | .945 | .946 | .947 | .948 | .949 | | | | | |
| 106.......... | .946 | .947 | .948 | .949 | .950 | | | | | |
| 108.......... | .947 | .948 | .949 | .950 | | | | | | |
| 110.......... | .947 | .948 | .949 | | | | | | | |
| 112.......... | .948 | .949 | .950 | | | | | | | |
| 114.......... | .949 | .950 | | | | | | | | |
| 116.......... | .949 | | | | | | | | | |
| 118.......... | .950 | | | | | | | | | |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.940 | 0.941 | 0.942 | 0.943 | 0.944 | 0.945 | 0.946 | 0.947 | 0.948 | 0.949 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30 | 0.929 | 0.930 | 0.931 | 0.932 | 0.933 | 0.934 | 0.935 | 0.936 | 0.937 | 0.938 |
| 32 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 |
| 34 | .930 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 |
| 36 | .931 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 |
| 38 | .932 | .933 | .934 | .935 | .936 | .937 | .938 | .939 | .940 | .941 |
| 40 | .9330 | .9340 | .9350 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 |
| 42 | .9335 | .9345 | .9355 | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 |
| 44 | .9345 | .9355 | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 | .9435 |
| 46 | .9350 | .93[illegible]0 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 | .9440 |
| 48 | .9360 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 | .9440 | .9450 |
| 50 | .9365 | .9375 | .9385 | .9395 | .9405 | .9415 | .9425 | .9435 | .9445 | .9455 |
| 52 | .9370 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 | .9440 | .9450 | .9460 |
| 54 | .9380 | .9390 | .9400 | .9410 | .9420 | .9430 | .9440 | .9450 | .9460 | .9470 |
| 56 | .9385 | .9395 | .9405 | .9415 | .9425 | .9435 | .9445 | .9455 | .9465 | .9475 |
| 58 | .9395 | .9405 | .9415 | .9425 | .9435 | .9445 | .9455 | .9465 | .9475 | .9485 |
| 60 | .9400 | .9410 | .9420 | .9430 | .9440 | .9450 | .9460 | .9470 | .9480 | .9490 |
| 62 | .9405 | .9415 | .9425 | .9435 | .9445 | .9455 | .9465 | .9475 | .9485 | .9495 |
| 64 | .9415 | .9425 | .9435 | .9445 | .9455 | .9465 | .9475 | .9485 | .9495 | .9500 |
| 66 | .9420 | .9430 | .9440 | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | |
| 68 | .9430 | .9440 | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | | |
| 70 | .9435 | .9445 | .9455 | .9465 | .9475 | .9485 | .9495 | | | |
| 72 | .9440 | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | | | |
| 74 | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | | | | |
| 76 | .9455 | .9465 | .9475 | .9485 | .9495 | | | | | |
| 78 | .9465 | .9475 | .9485 | .9495 | .9500 | | | | | |
| 80 | .947 | .948 | .949 | .950 | | | | | | |
| 82 | .947 | .948 | .949 | | | | | | | |
| 84 | .948 | .949 | .950 | | | | | | | |
| 86 | .949 | .950 | | | | | | | | |
| 88 | .950 | | | | | | | | | |

## REDUCTION OF SPECIFIC GRAVITY READINGS TO 60°F—Con.

| Observed temperature in °F | Observed specific gravities | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.950 | 0.951 | 0.952 | 0.953 | 0.954 | 0.955 | 0.956 | 0.957 | 0.958 | 0.959 |
| | Corresponding specific gravities at 60°/60° F | | | | | | | | | |
| 30.......... | 0.939 | 0.940 | 0.941 | 0.942 | 0.943 | 0.944 | 0.945 | 0.946 | 0.947 | 0.948 |
| 32.......... | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 |
| 34.......... | .940 | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 |
| 36.......... | .941 | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 |
| 38.......... | .942 | .943 | .944 | .945 | .946 | .947 | .948 | .949 | .950 | |
| 40.......... | .9430 | .9440 | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | | |
| 42.......... | .9435 | .9445 | .9455 | .9465 | .9475 | .9485 | .9495 | | | |
| 44.......... | .9445 | .9455 | .9465 | .9475 | .9485 | .9495 | .9500 | | | |
| 46.......... | .9450 | .9460 | .9470 | .9480 | .9490 | .9500 | | | | |
| 48.......... | .9460 | .9470 | .9480 | .9490 | .9500 | | | | | |
| 50.......... | .9465 | .9475 | .9485 | .9495 | | | | | | |
| 52.......... | .9470 | .9480 | .9490 | .9500 | | | | | | |
| 54.......... | .9480 | .9490 | .9500 | | | | | | | |
| 56.......... | .9485 | .9495 | | | | | | | | |
| 58.......... | .9495 | .9500 | | | | | | | | |
| 60.......... | .9500 | | | | | | | | | |

# Specific Gravity Tables

**Equivalent of Degrees Baume′ (American Standard) and Specific Gravity at 60°F.**

$$\text{Degrees Baume}' = 145 - \frac{145}{\text{Sp. Gr.}} \quad \text{For Liquids Heavier than Water}$$

| Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity |
|---|---|---|---|---|---|---|---|
| 0.0 | 1.0000 | .7 | 1.0262 | .4 | 1.0538 | .1 | 1.0829 |
| .1 | 1.0007 | .8 | 1.0269 | .5 | 1.0545 | .2 | 1.0837 |
| .2 | 1.0014 | .9 | 1.0276 | .6 | 1.0553 | .3 | 1.0845 |
| .3 | 1.0021 | 4.0 | 1.0284 | .7 | 1.0561 | .4 | 1.0853 |
| .4 | 1.0028 | .1 | 1.0291 | .8 | 1.0569 | .5 | 1.0861 |
| .5 | 1.0035 | .2 | 1.0298 | .9 | 1.0576 | .6 | 1.0870 |
| .6 | 1.0042 | .3 | 1.0306 | 8.0 | 1.0584 | .7 | 1.0878 |
| .7 | 1.0049 | .4 | 1.0313 | .1 | 1.0592 | .8 | 1.0886 |
| .8 | 1.0055 | .5 | 1.0320 | .2 | 1.0599 | .9 | 1.0894 |
| .9 | 1.0062 | .6 | 1.0328 | .3 | 1.0607 | 12.0 | 1.0902 |
| 1.0 | 1.0069 | .7 | 1.0335 | .4 | 1.0615 | .1 | 1.0910 |
| .1 | 1.0076 | .8 | 1.0342 | .5 | 1.0623 | .2 | 1.0919 |
| .2 | 1.0083 | .9 | 1.0350 | .6 | 1.0630 | .3 | 1.0927 |
| .3 | 1.0090 | 5.0 | 1.0357 | .7 | 1.0638 | .4 | 1.0935 |
| .4 | 1.0097 | .1 | 1.0365 | .8 | 1.0646 | .5 | 1.0943 |
| .5 | 1.0105 | .2 | 1.0372 | .9 | 1.0654 | .6 | 1.0952 |
| .6 | 1.0112 | .3 | 1.0379 | 9.0 | 1.0662 | .7 | 1.0960 |
| .7 | 1.0119 | .4 | 1.0387 | .1 | 1.0670 | .8 | 1.0968 |
| .8 | 1.0126 | .5 | 1.0394 | .2 | 1.0677 | .9 | 1.0977 |
| .9 | 1.0133 | .6 | 1.0402 | .3 | 1.0685 | 13.0 | 1.0985 |
| 2.0 | 1.0140 | .7 | 1.0409 | .4 | 1.0693 | .1 | 1.0993 |
| .1 | 1.0147 | .8 | 1.0417 | .5 | 1.0701 | .2 | 1.1002 |
| .2 | 1.0154 | .9 | 1.0424 | .6 | 1.0709 | .3 | 1.1010 |
| .3 | 1.0161 | 6.0 | 1.0432 | .7 | 1.0717 | .4 | 1.1018 |
| .4 | 1.0168 | .1 | 1.0439 | .8 | 1.0725 | .5 | 1.1027 |
| .5 | 1.0175 | .2 | 1.0447 | .9 | 1.0733 | .6 | 1.1035 |
| .6 | 1.0183 | .3 | 1.0454 | 10.0 | 1.0741 | .7 | 1.1043 |
| .7 | 1.0190 | .4 | 1.0462 | .1 | 1.0749 | .8 | 1.1052 |
| .8 | 1.0197 | .5 | 1.0469 | .2 | 1.0757 | .9 | 1.1060 |
| .9 | 1.0204 | .6 | 1.0477 | .3 | 1.0765 | 14.0 | 1.1069 |
| 3.0 | 1.0211 | .7 | 1.0484 | .4 | 1.0773 | .1 | 1.1077 |
| .1 | 1.0218 | .8 | 1.0492 | .5 | 1.0781 | .2 | 1.1086 |
| .2 | 1.0226 | .9 | 1.0500 | .6 | 1.0789 | .3 | 1.1094 |
| .3 | 1.0233 | 7.0 | 1.0507 | .7 | 1.0797 | .4 | 1.1103 |
| .4 | 1.0240 | .1 | 1.0515 | .8 | 1.0805 | .5 | 1.1111 |
| .5 | 1.0247 | .2 | 1.0522 | .9 | 1.0813 | .6 | 1.1120 |
| .6 | 1.0255 | .3 | 1.0530 | 11.0 | 1.0821 | .7 | 1.1128 |

## EQUIVALENT BAUME′ DEGREES—Con.

| Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity |
|---|---|---|---|---|---|---|---|
| .8 | 1.1137 | .2 | 1.1526 | .6 | 1.1944 | 28.0 | 1.2393 |
| .9 | 1.1145 | .3 | 1.1535 | .7 | 1.1954 | .1 | 1.2404 |
| 15.0 | 1.1154 | .4 | 1.1545 | .8 | 1.1964 | .2 | 1.2414 |
| .1 | 1.1162 | .5 | 1.1554 | .9 | 1.1974 | .3 | 1.2425 |
| .2 | 1.1171 | .6 | 1.1563 | 24.0 | 1.1983 | .4 | 1.2436 |
| .3 | 1.1180 | .7 | 1.1572 | .1 | 1.1993 | .5 | 1.2446 |
| .4 | 1.1188 | .8 | 1.1581 | .2 | 1.2003 | .6 | 1.2457 |
| .5 | 1.1197 | .9 | 1.1591 | .3 | 1.2013 | .7 | 1.2468 |
| .6 | 1.1206 | 20.0 | 1.1600 | .4 | 1.2023 | .8 | 1.2478 |
| .7 | 1.1214 | .1 | 1.1609 | .5 | 1.2033 | .9 | 1.2489 |
| .8 | 1.1223 | .2 | 1.1619 | .6 | 1.2043 | 29.0 | 1.2500 |
| .9 | 1.1232 | .3 | 1.1628 | .7 | 1.2053 | .1 | 1.2511 |
| 16.0 | 1.1240 | .4 | 1.1637 | .8 | 1.2063 | .2 | 1.2522 |
| .1 | 1.1249 | .5 | 1.1647 | .9 | 1.2073 | .3 | 1.2532 |
| .2 | 1.1258 | .6 | 1.1656 | 25.0 | 1.2083 | .4 | 1.2543 |
| .3 | 1.1267 | .7 | 1.1665 | .1 | 1.2093 | .5 | 1.2554 |
| .4 | 1.1275 | .8 | 1.1675 | .2 | 1.2104 | .6 | 1.2565 |
| .5 | 1.1284 | .9 | 1.1684 | .3 | 1.2114 | .7 | 1.2576 |
| .6 | 1.1293 | 21.0 | 1.1694 | .4 | 1.2124 | .8 | 1.2587 |
| .7 | 1.1302 | .1 | 1.1703 | .5 | 1.2134 | .9 | 1.2598 |
| .8 | 1.1310 | .2 | 1.1712 | .6 | 1.2144 | 30.0 | 1.2609 |
| .9 | 1.1319 | .3 | 1.1722 | .7 | 1.2154 | .1 | 1.2620 |
| 17.0 | 1.1328 | .4 | 1.1731 | .8 | 1.2164 | .2 | 1.2631 |
| .1 | 1.1337 | .5 | 1.1741 | .9 | 1.2175 | .3 | 1.2642 |
| .2 | 1.1346 | .6 | 1.1750 | 26.0 | 1.2185 | .4 | 1.2653 |
| .3 | 1.1355 | .7 | 1.1760 | .1 | 1.2195 | .5 | 1.2664 |
| .4 | 1.1364 | .8 | 1.1769 | .2 | 1.2205 | .6 | 1.2675 |
| .5 | 1.1373 | .9 | 1.1779 | .3 | 1.2216 | .7 | 1.2686 |
| .6 | 1.1381 | 22.0 | 1.1789 | .4 | 1.2226 | .8 | 1.2697 |
| .7 | 1.1390 | .1 | 1.1798 | .5 | 1.2236 | .9 | 1.2708 |
| .8 | 1.1399 | .2 | 1 1808 | .6 | 1.2247 | 31.0 | 1.2719 |
| .9 | 1.1408 | .3 | 1.1817 | .7 | 1.2257 | .1 | 1.2730 |
| 18.0 | 1.1417 | .4 | 1.1827 | .8 | 1.2267 | .2 | 1.2742 |
| .1 | 1.1426 | .5 | 1.1837 | .9 | 1.2278 | .3 | 1.2753 |
| .2 | 1.1435 | .6 | 1.1846 | 27.0 | 1.2288 | .4 | 1.2764 |
| .3 | 1.1444 | .7 | 1.1856 | .1 | 1.2299 | .5 | 1.2775 |
| .4 | 1.1453 | .8 | 1.1866 | .2 | 1.2309 | .6 | 1.2787 |
| .5 | 1.1462 | .9 | 1.1876 | .3 | 1.2319 | .7 | 1.2798 |
| .6 | 1.1472 | 23.0 | 1.1885 | .4 | 1.2330 | .8 | 1.2809 |
| .7 | 1.1481 | .1 | 1.1895 | .5 | 1.2340 | .9 | 1.2821 |
| .8 | 1.1490 | .2 | 1.1905 | .6 | 1.2351 | 32.0 | 1.2832 |
| .9 | 1.1499 | .3 | 1.1915 | .7 | 1.2361 | .1 | 1.2843 |
| 19.0 | 1.1508 | .4 | 1.1924 | .8 | 1.2372 | .2 | 1,2855 |
| .1 | 1.1517 | .5 | 1.1934 | .9 | 1.2383 | .3 | 1.2866 |

## EQUIVALENT BAUME′ DEGREES—Con.

| Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity |
|---|---|---|---|---|---|---|---|
| .4 | 1.2877 | .8 | 1.3401 | .2 | 1.3969 | .6 | 1.4588 |
| .5 | 1.2889 | .9 | 1.3414 | .3 | 1.3983 | .7 | 1.4602 |
| .6 | 1.2900 | 37.0 | 1.3426 | .4 | 1.3996 | .8 | 1.4617 |
| .7 | 1.2912 | .1 | 1.3438 | .5 | 1.4010 | .9 | 1.4632 |
| .8 | 1.2923 | .2 | 1.3451 | .6 | 1.4023 | 46.0 | 1.4646 |
| .9 | 1.2935 | .3 | 1.3463 | .7 | 1.4037 | .1 | 1.4661 |
| 33.0 | 1.2946 | .4 | 1.3476 | .8 | 1.4050 | .2 | 1.4676 |
| .1 | 1.2958 | .5 | 1.3488 | .9 | 1.4064 | .3 | 1.4691 |
| .2 | 1.2970 | .6 | 1.3501 | 42.0 | 1.4078 | .4 | 1.4706 |
| .3 | 1.2981 | .7 | 1.3514 | .1 | 1.4091 | .5 | 1.4721 |
| .4 | 1.2993 | .8 | 1.3526 | .2 | 1.4105 | .6 | 1.4736 |
| .5 | 1.3004 | .9 | 1.3539 | .3 | 1.4119 | .7 | 1.4751 |
| .6 | 1.3016 | 38.0 | 1.3551 | .4 | 1.4133 | .8 | 1.4766 |
| .7 | 1.3028 | .1 | 1.3564 | .5 | 1.4146 | .9 | 1.4781 |
| .8 | 1.3040 | .2 | 1.3577 | .6 | 1.4160 | 47.0 | 1.4796 |
| .9 | 1.3051 | .8 | 1.3 53 | .7 | 1.4174 | .1 | 1.4811 |
| 34.0 | 1.3063 | .4 | 1.3602 | .8 | 1.4188 | .2 | 1.4826 |
| .1 | 1.3075 | .5 | 1.3615 | .9 | 1.4202 | .3 | 1.4841 |
| .2 | 1.3087 | .6 | 1.3628 | 43.0 | 1,4216 | .4 | 1.4857 |
| .3 | 1.3098 | .7 | 1.3641 | .1 | 1.4230 | .5 | 1.4872 |
| .4 | 1.3110 | .8 | 1.3653 | .2 | 1.4244 | .6 | 1.4887 |
| .5 | 1.3122 | .9 | 1.3666 | .3 | 1.4258 | .7 | 1.4902 |
| .6 | 1.3134 | 39.0 | 1.3679 | .4 | 1.4272 | .8 | 1.4918 |
| .7 | 1.3146 | .1 | 1.3692 | .5 | 1.4286 | .9 | 1.4933 |
| .8 | 1.3158 | .2 | 1.3705 | .6 | 1.4300 | 48.0 | 1.4948 |
| 9 | 1.3170 | .3 | 1.3718 | .7 | 1.4314 | .1 | 1.4964 |
| 35.0 | 1.3182 | .4 | 1.3731 | .8 | 1.4328 | .2 | 1.4979 |
| .1 | 1.3194 | .5 | 1.3744 | .9 | 1.4342 | .3 | 1.4995 |
| .2 | 1.3206 | .6 | 1.3757 | 44.0 | 1.4356 | .4 | 1.5010 |
| .3 | 1.3218 | .7 | 1.3770 | .1 | 1.4371 | .5 | 1.5026 |
| .4 | 1.3230 | .8 | 1.3783 | .2 | 1.4385 | .6 | 1.5041 |
| .5 | 1.3242 | .9 | 1.3796 | .3 | 1.4399 | .7 | 1.5057 |
| .6 | 1.3254 | 40.0 | 1.3810 | .4 | 1.4414 | .8 | 1.5073 |
| .7 | 1.3266 | .1 | 1.3823 | .5 | 1.4428 | .9 | 1.5088 |
| .8 | 1.3278 | .2 | 1 3836 | .6 | 1.4442 | 49.0 | 1.5104 |
| .9 | 1.3291 | .3 | 1.3849 | .7 | 1.4457 | .1 | 1.5120 |
| 36.0 | 1.3303 | .4 | 1.3862 | .8 | 1.4471 | .2 | 1.5136 |
| .1 | 1.3315 | .5 | 1.3876 | .9 | 1.4486 | .3 | 1.5152 |
| .2 | 1.3327 | .6 | 1.3889 | 45.0 | 1.4500 | .4 | 1.5167 |
| .3 | 1.3329 | .7 | 1.3902 | .1 | 1.4515 | .5 | 1.5183 |
| .4 | 1.3352 | .8 | 1.3916 | .2 | 1.4529 | .6 | 1.5199 |
| .5 | 1.3364 | .9 | 1.3828 | .3 | 1.4544 | .7 | 1.5215 |
| .6 | 1.3376 | 41.0 | 1.3942 | .4 | 1.4558 | .8 | 1.5231 |
| .7 | 1.3389 | .1 | 1.3956 | .5 | 1.4573 | .9 | 1.5247 |

## EQUIVALENT BAUME′ DEGREES—Con.

| Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity | Degrees Baume′ | Specific Gravity |
|---|---|---|---|---|---|---|---|
| 50.0 | 1.5263 | .1 | 1.6129 | .1 | 1.7079 | .1 | 1.8148 |
| .1 | 1.5279 | .2 | 1.6147 | .2 | 1.7099 | .2 | 1.8170 |
| .2 | 1.5295 | .3 | 1.6165 | .3 | 1.7119 | .3 | 1.8193 |
| .3 | 1.5312 | .4 | 1.6183 | .4 | 1.7139 | .4 | 1.8216 |
| .4 | 1.5328 | .5 | 1.6201 | .5 | 1.7160 | .5 | 1.8239 |
| .5 | 1.5344 | .6 | 1.6219 | .6 | 1.7180 | .6 | 1.8262 |
| .6 | 1.5360 | .7 | 1.6237 | .7 | 1.7200 | .7 | 1.8285 |
| .7 | 1.5376 | .8 | 1.6256 | .8 | 1.7221 | .8 | 1.8308 |
| .8 | 1.5393 | .9 | 1.6459 | .9 | 1.7241 | .9 | 1.8331 |
| .9 | 1.5409 | 56.0 | 1.6292 | 61.0 | 1.7262 | 66.0 | 1.8354 |
| 51.0 | 1.5426 | .1 | 1.6310 | .1 | 1.7282 | .1 | 1.8378 |
| .1 | 1.5442 | .2 | 1.6329 | .2 | 1.7303 | .2 | 1.8401 |
| .2 | 1.5458 | .3 | 1.6347 | .3 | 1.7324 | .3 | 1.8424 |
| .3 | 1.5475 | .4 | 1.6366 | .4 | 1.7344 | .4 | 1.8448 |
| .4 | 1.5491 | .5 | 1.6384 | .5 | 1.7365 | .5 | 1.8471 |
| .5 | 1.5508 | .6 | 1.6403 | .6 | 1.7386 | .6 | 1.8495 |
| .6 | 1.5525 | .7 | 1.6421 | .7 | 1.7407 | .7 | 1.8519 |
| .7 | 1.5541 | .8 | 1.6440 | .8 | 1.7428 | .8 | 1.8542 |
| .8 | 1.5558 | .9 | 1.6459 | .9 | 1.7449 | 9 | 1.8566 |
| .9 | 1.5575 | 57.0 | 1.6477 | 62.0 | 1.7470 | 67.0 | 1.8590 |
| 52.0 | 1.5591 | .1 | 1.6496 | .1 | 1.7491 | .1 | 1.8614 |
| .1 | 1.5608 | .2 | 1.6515 | .2 | 1.7512 | .2 | 1.8638 |
| .2 | 1.5625 | .3 | 1.6534 | .3 | 1.7533 | .3 | 1.8662 |
| .3 | 1.5642 | .4 | 1.6553 | .4 | 1.7554 | .4 | 1.8686 |
| .4 | 1.5659 | .5 | 1.6571 | .5 | 1.7576 | .5 | 1.8710 |
| .5 | 1.5676 | .6 | 1.6590 | .6 | 1.7597 | .6 | 1.8734 |
| .6 | 1.5693 | .7 | 1.6609 | .7 | 1.7618 | .7 | 1.8758 |
| .7 | 1.5710 | .8 | 1.6628 | .8 | 1.7640 | .8 | 1.8782 |
| .8 | 1.5727 | .9 | 1.6459 | .9 | 1.7661 | .9 | 1.8807 |
| .9 | 1.5744 | 58.0 | 1.6667 | 63.0 | 1.7683 | 68.0 | 1.8831 |
| 53.0 | 1.5761 | .1 | 1.6686 | .1 | 1.7705 | .1 | 1.8856 |
| .1 | 1.5778 | .2 | 1.6705 | .2 | 1.7726 | .2 | 1.8880 |
| .2 | 1.5795 | .3 | 1.6724 | .3 | 1.7748 | .3 | 1,8905 |
| .3 | 1.5812 | .4 | 1.6744 | .4 | 1.7770 | .4 | 1.8930 |
| .4 | 1.5830 | .5 | 1.6763 | .5 | 1.7791 | .5 | 1.8954 |
| .5 | 1.5847 | .6 | 1.6782 | .6 | 1.7813 | .6 | 1.8979 |
| .6 | 1.5864 | .7 | 1.6802 | .7 | 1.7835 | .7 | 1.9004 |
| .7 | 1.5882 | .8 | 1.6821 | .8 | 1.7857 | .8 | 1.9029 |
| .8 | 1.5899 | .9 | 1.6841 | .9 | 1.7879 | .9 | 1.9054 |
| .9 | 1.5917 | 59.0 | 1.6860 | 64.0 | 1.7901 | 69.0 | 1.9079 |
| 54.0 | 1.5934 | .1 | 1.6880 | .1 | 1.7923 | .1 | 1.9104 |
| .1 | 1.5952 | .2 | 1.6900 | .2 | 1.7946 | .2 | 1.9129 |
| .2 | 1.5969 | .3 | 1.6919 | .3 | 1.7968 | .3 | 1.9155 |
| .3 | 1.5987 | .4 | 1,6939 | .4 | 1.7990 | .4 | 1.9180 |
| .4 | 1.6004 | .5 | 1.6959 | .5 | 1.8012 | .5 | 1.9205 |
| .5 | 1.6022 | .6 | 1.6979 | .6 | 1.8035 | .6 | 1.9231 |
| .6 | 1.6040 | .7 | 1.6999 | .7 | 1.8057 | .7 | 1.9256 |
| .7 | 1.6058 | .8 | 1.7019 | .8 | 1.8080 | .8 | 1.9282 |
| .8 | 1.6075 | .9 | 1.7039 | .9 | 1.8102 | .9 | 1.9308 |
| .9 | 1.6093 | 60.0 | 1.7059 | 65.0 | 1.8125 | 70.0 | 1.9333 |
| 55.0 | 1.6111 | | | | | | |

# Specific Gravity and Content of Sulphuric Acid

| Specific Gravity $\frac{15°}{4°}$ in vacuo | 100 parts by weight correspond to % $SO_3$ | 100 parts by weight correspond to % $H_2SO_4$ | 1 liter contains grams $SO_3$ | 1 liter contains grams $H_2SO_4$ | Specific Gravity $\frac{15°}{4°}$ in vacuo | 100 parts by weight correspond to % $SO_3$ | 100 parts by weight correspond to % $H_2SO_4$ | 1 liter contains grams $SO_3$ | 1 liter contains grams $H_2SO_4$ |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | 0.07 | 0.09 | 1 | 1 | 1.190 | 21.26 | 26.04 | 253 | 310 |
| 1.005 | 0.68 | 0.83 | 7 | 8 | 1.195 | 21.78 | 26.68 | 260 | 319 |
| 1.010 | 1.28 | 1.57 | 13 | 16 | 1.200 | 22.30 | 27.30 | 268 | 328 |
| 1.015 | 1.88 | 2.30 | 19 | 23 | 1.205 | 22.82 | 27.95 | 275 | 337 |
| 1.020 | 2.47 | 3.03 | 25 | 31 | 1.210 | 23.33 | 28.58 | 282 | 346 |
| 1.025 | 3.07 | 3.76 | 32 | 39 | 1.215 | 23.84 | 29.21 | 290 | 355 |
| 1.030 | 3.67 | 4.40 | 38 | 46 | 1.220 | 24.36 | 29.84 | 297 | 364 |
| 1.035 | 4.27 | 5.23 | 44 | 54 | 1.225 | 24.88 | 30.48 | 305 | 373 |
| 1.040 | 4.87 | 5.96 | 51 | 62 | 1.230 | 25.39 | 31.11 | 312 | 382 |
| 1.045 | 5.45 | 6.67 | 57 | 71 | 1.235 | 25.88 | 31.70 | 320 | 391 |
| 1.050 | 6.02 | 7.37 | 63 | 77 | 1.240 | 26.35 | 32.28 | 327 | 400 |
| 1.055 | 6.59 | 8.07 | 70 | 85 | 1.245 | 26.83 | 32.86 | 334 | 409 |
| 1.060 | 7.16 | 8.77 | 76 | 93 | 1.250 | 27.29 | 33.43 | 341 | 418 |
| 1.065 | 7.73 | 9.47 | 82 | 102 | 1.255 | 27.76 | 34.00 | 348 | 426 |
| 1.070 | 8.32 | 10.19 | 89 | 109 | 1.260 | 28.22 | 34.57 | 356 | 435 |
| 1.075 | 8.90 | 10.90 | 96 | 117 | 1.265 | 28.69 | 35.14 | 363 | 444 |
| 1.080 | 9.47 | 11.60 | 103 | 125 | 1.270 | 29.15 | 35.71 | 370 | 454 |
| 1.085 | 10.04 | 12.30 | 109 | 133 | 1.275 | 29.62 | 36.29 | 377 | 462 |
| 1.090 | 10.60 | 12.99 | 116 | 142 | 1.280 | 30.10 | 36.87 | 385 | 472 |
| 1.095 | 11.16 | 13.67 | 122 | 150 | 1.285 | 30.57 | 37.45 | 393 | 481 |
| 1.100 | 11.71 | 14.35 | 129 | 158 | 1.290 | 31.04 | 38.03 | 400 | 490 |
| 1.105 | 12.27 | 15.03 | 136 | 166 | 1.295 | 31.52 | 38.61 | 408 | 500 |
| 1.110 | 12.82 | 15.71 | 143 | 175 | 1.300 | 31.99 | 39.19 | 416 | 510 |
| 1.115 | 13.36 | 16.36 | 149 | 183 | 1.305 | 32.46 | 39.77 | 424 | 519 |
| 1.120 | 13.89 | 17.01 | 156 | 191 | 1.310 | 32.94 | 40.35 | 432 | 529 |
| 1.125 | 14.42 | 17.66 | 162 | 199 | 1.315 | 33.41 | 40.93 | 439 | 538 |
| 1.130 | 14.95 | 18.31 | 169 | 207 | 1.320 | 33.88 | 41.50 | 447 | 548 |
| 1.135 | 15.48 | 18.96 | 176 | 215 | 1.325 | 34.35 | 42.08 | 455 | 557 |
| 1.140 | 16.01 | 19.61 | 183 | 223 | 1.330 | 34.80 | 42.66 | 462 | 507 |
| 1.145 | 16.54 | 20.26 | 189 | 231 | 1.335 | 35.27 | 43.20 | 471 | 577 |
| 1.150 | 17.07 | 20.91 | 196 | 239 | 1.340 | 35.71 | 43.74 | 479 | 586 |
| 1.155 | 17.59 | 21.55 | 203 | 248 | 1.345 | 36.14 | 44.28 | 486 | 596 |
| 1.160 | 18.11 | 22.19 | 210 | 257 | 1.350 | 36.58 | 44.82 | 494 | 605 |
| 1.165 | 18.64 | 22.83 | 217 | 266 | 1.355 | 37.02 | 45.35 | 502 | 614 |
| 1.170 | 19.16 | 23.47 | 224 | 275 | 1.360 | 37.45 | 45.88 | 509 | 624 |
| 1.175 | 19.69 | 24.12 | 231 | 283 | 1.365 | 37.89 | 46.41 | 517 | 633 |
| 1.180 | 20.21 | 24.76 | 238 | 292 | 1.370 | 38.32 | 46.94 | 525 | 643 |
| 1.185 | 20.73 | 25.40 | 246 | 301 | 1.375 | 38.75 | 47.47 | 533 | 653 |

## SPECIFIC GRAVITY AND CONTENT OF SULPHURIC ACID—Con.

| Specific Gravity $\frac{15^\circ}{4^\circ}$ in vacuo | 100 parts by weight correspond to | | 1 liter contains grams | | Specific Gravity $\frac{15^\circ}{4^\circ}$ in vacuo | 100 parts by weight correspond to | | 1 liter contains grams | |
|---|---|---|---|---|---|---|---|---|---|
| | % $SO_3$ | % $H_2SO_4$ | $SO_3$ | $H_2SO_4$ | | % $SO_3$ | % $H_2SO_4$ | $SO_3$ | $H_2SO_4$ |
| 1.380 | 39.18 | 48.00 | 541 | 662 | 1.675 | 61.20 | 74.97 | 1025 | 1256 |
| 1.385 | 39.62 | 48.53 | 549 | 672 | 1.680 | 61.57 | 75.42 | 1034 | 1267 |
| 1.390 | 40.05 | 49.06 | 557 | 682 | 1.685 | 61.93 | 75.86 | 1043 | 1278 |
| 1.395 | 40.48 | 49.50 | 564 | 692 | 1.690 | 62.29 | 76.30 | 1053 | 1289 |
| 1.400 | 40.91 | 50.11 | 573 | 702 | 1.695 | 62.64 | 76.73 | 1062 | 1301 |
| 1.405 | 41.33 | 50.63 | 581 | 711 | 1.700 | 63.00 | 77.17 | 1071 | 1312 |
| 1.410 | 41.76 | 51.15 | 589 | 721 | 1.705 | 63.35 | 77.60 | 1080 | 1323 |
| 1.415 | 42.17 | 51.66 | 597 | 730 | 1.710 | 63.70 | 78.04 | 1089 | 1334 |
| 1.420 | 42.57 | 52.15 | 604 | 740 | 1.715 | 64.07 | 78.48 | 1099 | 1346 |
| 1.425 | 42.96 | 52.63 | 612 | 750 | 1.720 | 64.43 | 78.92 | 1108 | 1357 |
| 1.430 | 43.36 | 53.11 | 620 | 759 | 1.725 | 64.78 | 79.36 | 1118 | 1369 |
| 1.435 | 43.75 | 53.59 | 628 | 769 | 1.730 | 65.14 | 79.80 | 1127 | 1381 |
| 1.440 | 44.14 | 54.07 | 636 | 779 | 1.735 | 65.50 | 80.24 | 1136 | 1392 |
| 1.445 | 44.53 | 54.55 | 643 | 789 | 1.740 | 65.86 | 80.68 | 1146 | 1404 |
| 1.450 | 44.92 | 55.03 | 651 | 798 | 1.745 | 66.22 | 81.12 | 1156 | 1416 |
| 1.455 | 45.31 | 55.50 | 659 | 808 | 1.750 | 66.58 | 81.56 | 1165 | 1427 |
| 1.460 | 45.69 | 55.97 | 667 | 817 | 1.755 | 66.94 | 82.00 | 1175 | 1439 |
| 1.465 | 46.07 | 56.43 | 675 | 827 | 1.760 | 67.30 | 82.44 | 1185 | 1451 |
| 1.470 | 46.45 | 56.90 | 683 | 837 | 1.765 | 67.65 | 82.88 | 1194 | 1463 |
| 1.475 | 46.83 | 57.37 | 691 | 846 | 1.770 | 68.02 | 83.32 | 1204 | 1475 |
| 1.480 | 47.21 | 57.83 | 699 | 856 | 1.775 | 68.49 | 83.90 | 1216 | 1489 |
| 1.485 | 47.57 | 58.28 | 707 | 865 | 1.780 | 68.98 | 84.50 | 1228 | 1504 |
| 1.490 | 47.95 | 58.74 | 715 | 876 | 1.785 | 69.47 | 85.10 | 1240 | 1519 |
| 1.495 | 48.34 | 59.22 | 723 | 885 | 1.790 | 69.96 | 85.70 | 1252 | 1534 |
| 1.500 | 48.73 | 59.70 | 731 | 896 | 1.795 | 70.46 | 86.30 | 1265 | 1549 |
| 1.505 | 49.12 | 60.18 | 739 | 906 | 1.800 | 70.94 | 86.90 | 1277 | 1564 |
| 1.510 | 49.51 | 60.65 | 748 | 916 | 1.805 | 71.50 | 87.60 | 1291 | 1581 |
| 1.515 | 49.89 | 61.12 | 756 | 926 | 1.810 | 72.08 | 88.30 | 1305 | 1598 |
| 1.520 | 50.28 | 61.59 | 764 | 936 | 1.815 | 72.69 | 89.05 | 1319 | 1621 |
| 1.525 | 50.66 | 62.06 | 773 | 946 | 1.820 | 73.51 | 90.05 | 1338 | 1639 |
| 1.530 | 51.04 | 62.53 | 781 | 957 | 1.821 | 73.63 | 90.20 | 1341 | 1643 |
| 1.535 | 51.43 | 63.00 | 789 | 967 | 1.822 | 73.80 | 90.40 | 1345 | 1647 |
| 1.540 | 51.78 | 63.43 | 797 | 977 | 1.823 | 73.96 | 90.60 | 1348 | 1651 |
| 1.545 | 52.12 | 63.85 | 805 | 987 | 1.824 | 74.12 | 90.80 | 1352 | 1656 |
| 1.550 | 52.46 | 64.26 | 813 | 996 | 1.825 | 74.29 | 91.00 | 1356 | 1661 |
| 1.555 | 52.79 | 64.67 | 821 | 1006 | 1.826 | 74.49 | 91.25 | 1360 | 1666 |
| 1.560 | 53.12 | 65.08 | 829 | 1015 | 1.827 | 74.69 | 91.50 | 1364 | 1671 |
| 1.565 | 53.46 | 65.49 | 837 | 1025 | 1.828 | 74.86 | 91.70 | 1368 | 1676 |
| 1.570 | 53.80 | 65.90 | 845 | 1035 | 1.829 | 75.03 | 91.90 | 1372 | 1681 |
| 1.575 | 54.13 | 66.30 | 853 | 1044 | 1.830 | 75.19 | 92.10 | 1376 | 1685 |
| 1.580 | 54.46 | 66.71 | 861 | 1054 | 1.831 | 75.35 | 92.30 | 1380 | 1690 |
| 1.585 | 54.80 | 67.13 | 869 | 1064 | 1.832 | 75.53 | 92.52 | 1384 | 1695 |
| 1.590 | 55.18 | 67.59 | 877 | 1075 | 1.833 | 75.72 | 92.75 | 1388 | 1700 |
| 1.595 | 55.55 | 68.05 | 886 | 1085 | 1.834 | 75.96 | 93.05 | 1393 | 1706 |
| 1.600 | 55.93 | 68.51 | 897 | 1096 | 1.835 | 76.27 | 93.43 | 1400 | 1713 |
| 1.605 | 56.30 | 68.97 | 904 | 1107 | 1.836 | 76.57 | 93.80 | 1405 | 1722 |
| 1.610 | 56.68 | 69.43 | 913 | 1118 | 1.837 | 76.90 | 94.20 | 1412 | 1730 |
| 1.615 | 57.05 | 69.89 | 921 | 1128 | 1.838 | 77.23 | 94.60 | 1419 | 1739 |
| 1.620 | 57.40 | 70.32 | 930 | 1139 | 1.839 | 77.55 | 95.00 | 1426 | 1748 |
| 1.625 | 57.75 | 70.74 | 938 | 1150 | 1.840 | 78.04 | 95.60 | 1436 | 1759 |
| 1.630 | 58.09 | 71.16 | 947 | 1160 | 1.8405 | 78.33 | 95.95 | 1441 | 1765 |
| 1.635 | 58.43 | 71.57 | 955 | 1170 | 1.8410 | 79.19 | 97.00 | 1458 | 1786 |
| 1.640 | 58.77 | 71.99 | 964 | 1181 | 1,8415 | 79.76 | 97.70 | 1469 | 1799 |
| 1.645 | 59.10 | 72.40 | 972 | 1192 | 1.8410 | 80.16 | 98.20 | 1476 | 1808 |
| 1.650 | 59.45 | 72.82 | 981 | 1202 | 1.8405 | 80.57 | 98.70 | 1483 | 1816 |
| 1.655 | 59.78 | 73.23 | 989 | 1212 | 1.8400 | 80.98 | 99.20 | 1490 | 1825 |
| 1.660 | 60.11 | 73.64 | 998 | 1222 | 1.8395 | 81.18 | 99.45 | 1494 | 1830 |
| 1.665 | 60.46 | 74.07 | 1007 | 1233 | 1.8390 | 81.39 | 90.70 | 1497 | 1834 |
| 1.670 | 60.82 | 74.51 | 1016 | 1244 | 1.8385 | 81.59 | 99.95 | 1500 | 1838 |

# Percentage of Sulphur Trioxide and Sulphuric Acid in Fuming Sulphuric Acid

| Total $SO_3$ as found by titration | The acid contains % | | Total $SO_3$ as found by titration | The acid contains % | | Total as found by titration | The acid contains % | |
|---|---|---|---|---|---|---|---|---|
| | $H_2SO_4$ | $SO_3$ | | $H_2SO_4$ | $SO_3$ | | $H_2SO_4$ | $SO_3$ |
| 81.8326 | 100 | 0 | 87.8775 | 66 | 34 | 93.9389 | 33 | 67 |
| 81.8163 | 99 | 1 | 88.0612 | 65 | 35 | 94.1224 | 32 | 68 |
| 82.0000 | 98 | 2 | 88.2448 | 64 | 36 | 94.3061 | 31 | 69 |
| 82.1836 | 97 | 3 | 88.4285 | 63 | 37 | 94.4897 | 30 | 70 |
| 82.3674 | 96 | 4 | 88.6122 | 62 | 38 | 94.6734 | 29 | 71 |
| 82.5510 | 95 | 5 | 88.7959 | 61 | 39 | 94.8571 | 28 | 72 |
| 82.7346 | 94 | 6 | 88.9795 | 60 | 40 | 95.0408 | 27 | 73 |
| 82.9183 | 93 | 7 | 89.1632 | 59 | 41 | 95.2244 | 26 | 74 |
| 83.1020 | 92 | 8 | 89.3469 | 58 | 42 | 95.4081 | 25 | 75 |
| 83.2857 | 91 | 9 | 89.5306 | 57 | 43 | 95.5918 | 24 | 76 |
| 83.4693 | 90 | 10 | 89.7142 | 56 | 44 | 95.7755 | 23 | 77 |
| 83.6530 | 89 | 11 | 89.8979 | 55 | 45 | 95.9591 | 22 | 78 |
| 83.8367 | 88 | 12 | 90.0816 | 54 | 46 | 96.1428 | 21 | 79 |
| 84.0204 | 87 | 13 | 90.2653 | 53 | 47 | 96.3265 | 20 | 80 |
| 84.2040 | 86 | 14 | 90.4489 | 52 | 48 | 96.5102 | 19 | 81 |
| 84.3877 | 85 | 15 | 90.6326 | 51 | 49 | 96.6938 | 18 | 82 |
| 84.5714 | 84 | 16 | 90.8163 | 50 | 50 | 96.8775 | 17 | 83 |
| 84.7551 | 83 | 17 | 91.0000 | 49 | 51 | 97.0612 | 16 | 84 |
| 84.9387 | 82 | 18 | 91.1836 | 48 | 52 | 97.2448 | 15 | 85 |
| 85.1224 | 81 | 19 | 91.3673 | 47 | 53 | 97.4285 | 14 | 86 |
| 85.3061 | 80 | 20 | 91.5510 | 46 | 54 | 97.6122 | 13 | 87 |
| 85.4897 | 79 | 21 | 91.7346 | 45 | 55 | 97.7959 | 12 | 88 |
| 85.6734 | 78 | 22 | 91.9183 | 44 | 56 | 97.9795 | 11 | 89 |
| 85.8571 | 77 | 23 | 92.1020 | 43 | 57 | 98.1632 | 10 | 90 |
| 86.0408 | 76 | 24 | 92.2857 | 42 | 58 | 98.3469 | 9 | 91 |
| 86.2244 | 75 | 25 | 92.4693 | 41 | 59 | 98.5306 | 8 | 92 |
| 86.4081 | 74 | 26 | 92.6530 | 40 | 60 | 98.7142 | 7 | 93 |
| 86.5918 | 73 | 27 | 92.8367 | 39 | 61 | 98.8979 | 6 | 94 |
| 86.7755 | 72 | 28 | 93.0204 | 38 | 62 | 99.0816 | 5 | 95 |
| 86.9591 | 71 | 29 | 93.2040 | 37 | 63 | 99.2653 | 4 | 96 |
| 87.1428 | 70 | 30 | 93.3877 | 36 | 64 | 99.4489 | 3 | 97 |
| 87.3265 | 69 | 31 | 93.5714 | 35 | 65 | 99.6326 | 2 | 98 |
| 87.5102 | 68 | 32 | 93.7551 | 34 | 66 | 99.8163 | 1 | 99 |
| 87.6938 | 67 | 33 | | | | | | |

# Sodium Hydroxide Solution at 15°C (Caustic Soda)

LUNGE.

| Specific Gravity | Degrees Baume' | Degrees Twaddell | Per Cent $Na_2O$. | Per Cent NaOH. | 1 Liter Contains Grams | |
|---|---|---|---|---|---|---|
| | | | | | $Na_2O$. | NaOH. |
| 1.007 | 1.0 | 1.4 | 0.47 | 0.61 | 4 | 6 |
| 1.014 | 2.8 | 2.9 | 0.93 | 1.20 | 9 | 12 |
| 1.022 | 3.1 | 4.4 | 1.55 | 2.00 | 16 | 21 |
| 1.029 | 4.1 | 5.8 | 2.10 | 2.70 | 22 | 28 |
| 1.036 | 5.1 | 7.2 | 2.60 | 3.35 | 27 | 35 |
| 1.045 | 6.2 | 9.0 | 3.10 | 4.00 | 32 | 42 |
| 1.052 | 7.2 | 10.4 | 3.60 | 4.64 | 38 | 49 |
| 1.060 | 8.2 | 12.0 | 4.10 | 5.29 | 43 | 56 |
| 1.067 | 9.1 | 13.4 | 4.55 | 5.87 | 49 | 63 |
| 1.075 | 10.1 | 15.0 | 5.08 | 6.55 | 55 | 70 |
| 1.083 | 11.1 | 16.6 | 5.67 | 7.31 | 61 | 79 |
| 1.091 | 12.1 | 18.2 | 6.20 | 8.00 | 68 | 87 |
| 1.100 | 13.2 | 20.0 | 6.73 | 8.68 | 74 | 95 |
| 1.108 | 14.1 | 21.6 | 7.30 | 9.42 | 81 | 104 |
| 1.116 | 15.1 | 23.2 | 7.80 | 10.06 | 87 | 112 |
| 1.125 | 16.1 | 25.0 | 8.50 | 10.97 | 96 | 123 |
| 1.134 | 17.1 | 26.8 | 9.18 | 11.84 | 104 | 134 |
| 1.142 | 18.0 | 28.4 | 9.80 | 12.64 | 112 | 144 |
| 1.152 | 19.1 | 30.4 | 10.50 | 13.55 | 121 | 156 |
| 1.162 | 20.2 | 32.4 | 11.14 | 14.37 | 129 | 167 |
| 1.171 | 21.2 | 34.2 | 11.73 | 15.13 | 137 | 177 |
| 1.180 | 22.1 | 36.0 | 12.33 | 15.91 | 146 | 188 |
| 1.190 | 23.1 | 38.0 | 13.00 | 16.77 | 155 | 200 |
| 1.200 | 24.2 | 40.0 | 13.70 | 17.67 | 164 | 212 |
| 1.210 | 25.2 | 42.0 | 14.40 | 18.58 | 174 | 225 |
| 1.220 | 26.1 | 44.0 | 15.18 | 19.58 | 185 | 239 |
| 1.231 | 27.2 | 46.2 | 15.96 | 20.59 | 196 | 253 |
| 1.241 | 28.2 | 48.2 | 16.76 | 21.42 | 208 | 266 |
| 1.252 | 29.2 | 50.4 | 17.55 | 22.64 | 220 | 283 |
| 1.263 | 30.2 | 52.6 | 18.35 | 23.67 | 232 | 299 |
| 1.274 | 31.2 | 54.8 | 19.23 | 24.81 | 245 | 316 |
| 1.285 | 32.2 | 57.0 | 20.00 | 25.80 | 257 | 332 |
| 1.297 | 33.2 | 59.4 | 20.80 | 26.83 | 270 | 348 |
| 1.308 | 34.1 | 61.6 | 21.55 | 27.80 | 282 | 364 |
| 1.320 | 35.2 | 64.0 | 22.35 | 28.83 | 295 | 381 |
| 1.332 | 36.1 | 66.4 | 23.20 | 29.93 | 309 | 399 |
| 1.345 | 37.2 | 69.0 | 24.20 | 31.22 | 326 | 420 |
| 1.357 | 38.1 | 71.4 | 25.17 | 32.47 | 342 | 441 |
| 1.370 | 39.2 | 74.0 | 26.12 | 33.69 | 359 | 462 |
| 1.383 | 40.2 | 76.6 | 27.10 | 34.96 | 375 | 483 |
| 1.397 | 41.2 | 79.4 | 28.10 | 36.25 | 392 | 506 |
| 1.410 | 42.2 | 82.0 | 29.05 | 37.47 | 410 | 528 |
| 1.424 | 43.2 | 84.8 | 30.08 | 38.80 | 428 | 553 |
| 1.438 | 44.2 | 87.6 | 31.00 | 39.99 | 446 | 575 |
| 1.453 | 45.2 | 90.6 | 32.10 | 41.41 | 466 | 602 |
| 1.468 | 46.2 | 93.6 | 33.20 | 42.83 | 487 | 629 |
| 1.483 | 47.2 | 96.6 | 34.40 | 44.38 | 510 | 658 |
| 1.498 | 48.2 | 99.6 | 35.70 | 46.15 | 535 | 691 |
| 1.514 | 49.2 | 102.8 | 36.90 | 47.60 | 559 | 721 |
| 1.530 | 50.2 | 106.0 | 38.00 | 49.02 | 581 | 750 |

# Table of Chloride of Calcium Solution

| Specific Gravity at 64 Degrees F. | Degree Beaume at 64 Degrees F. | Degree Salometer at 64 Degrees F. | Per Cent of $CaCl_2$ | Freezing Point in Degrees F. | Ammonia Gauge Pressure Pounds per Square Inch |
|---|---|---|---|---|---|
| 1.007 | 1 | 4 | 0.943 | +31.20 | 46 |
| 1.014 | 2 | 8 | 1.886 | +30.40 | 45 |
| 1.021 | 3 | 12 | 2.829 | +29.60 | 44 |
| 1.028 | 4 | 16 | 3.772 | +28.80 | 43 |
| 1.035 | 5 | 20 | 4.715 | +28.00 | 42 |
| 1.043 | 6 | 24 | 5.658 | +26.80 | 41 |
| 1.050 | 7 | 28 | 6.601 | +25.78 | 40 |
| 1.058 | 8 | 32 | 7.544 | +24.67 | 38 |
| 1.065 | 9 | 36 | 8.487 | +23.56 | 37 |
| 1.073 | 10 | 40 | 9.430 | +22.09 | 35.5 |
| 1.081 | 11 | 44 | 10.373 | +20.62 | 34 |
| 1.089 | 12 | 48 | 11.316 | +19.14 | 32.5 |
| 1.097 | 13 | 52 | 12.259 | +17.67 | 30.5 |
| 1.105 | 14 | 56 | 13.202 | +15.75 | 29 |
| 1.114 | 15 | 60 | 14.145 | +13.82 | 27 |
| 1.122 | 16 | 64 | 15.088 | +11.80 | 25 |
| 1.131 | 17 | 68 | 16.031 | + 9.96 | 23.5 |
| 1.140 | 18 | 72 | 16.974 | + 7.68 | 21.5 |
| 1.149 | 19 | 76 | 17.917 | + 5.40 | 20 |
| 1.158 | 20 | 80 | 18.860 | + 3.12 | 18 |
| 1.167 | 21 | 84 | 19.803 | − 0.84 | 15 |
| 1.176 | 22 | 88 | 20.746 | − 4.44 | 12.5 |
| 1.186 | 23 | 92 | 21.689 | − 8.03 | 10.5 |
| 1.196 | 24 | 96 | 22.632 | −11.63 | 8 |
| 1.205 | 25 | 100 | 23.575 | −15.23 | 6 |
| 1.215 | 26 | 104 | 24.518 | −19.56 | 4 |
| 1.225 | 27 | 108 | 25.461 | −24.43 | 1.5 |
| 1.236 | 28 | 112 | 26.404 | −29.29 | 1″ vacuum |
| 1.246 | 29 | 116 | 27.347 | −35.30 | 5″ vacuum |
| 1.257 | 30 | 120 | 28.290 | −41.32 | 8.5″ vacuum |
| 1.268 | 31 | ...... | 29.233 | −47.66 | 12″ vacuum |
| 1.279 | 32 | ...... | 30.176 | −54.00 | 15″ vacuum |
| 1.290 | 33 | ...... | 31.119 | −44.32 | 10″ vacuum |
| 1.302 | 34 | ...... | 32.062 | −34.66 | 4″ vacuum |
| 1.313 | 35 | ...... | 33. | −25.00 | 1.5 pounds |

# Table of Brine Solution

(CHLORIDE OF SODIUM—COMMON SALT.)

| Per Cent of Salt by Weight | Degrees on Salometer at 60 Degrees Fahr. | Specific Gravity at 60 Degrees Fahr. | Specific Heat | Weight of One Gallon | Pounds of Salt in One Gallon | Pounds of Water in One Gallon | Weight of One Cubic Foot | Pounds of Salt in One Cubic Foot | Pounds of Water in One Cubic Foot | Freezing Point Degrees Fahr. |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1. | 1. | 8.35 | 0. | 8.35 | 62.4 | 0. | 62.4 | 32. |
| 1 | 4 | 1.007 | 0.992 | 8.4 | 0.084 | 8.316 | 62.8 | 0.628 | 62.172 | 31.8 |
| 5 | 20 | 1.037 | 0.96 | 8.65 | 0.432 | 8.218 | 64.7 | 3.237 | 61.465 | 25.4 |
| 10 | 40 | 1.073 | 0.892 | 8.95 | 0.895 | 8.055 | 66.95 | 6.695 | 60.253 | 18.6 |
| 15 | 60 | 1.115 | 0.855 | 9.3 | 1.395 | 7.905 | 69.57 | 10.435 | 59.134 | 12.2 |
| 20 | 80 | 1.150 | 0.829 | 9.6 | 1.92 | 7.68 | 71.76 | 14.352 | 57.408 | 6.86 |
| 25 | 100 | 1.191 | 0.783 | 9.94 | 2.485 | 7.455 | 74.26 | 18.565 | 55.695 | 1.00 |

# The Metric System, Fundamental Equivalents

The fundamental unit of the metric system is the Meter—the unit of length. From this the units of capacity (Liter) and of weight (Gram) were derived. All other units are the decimal subdivisions or multiples of these. These three units are simply related, e. g., for all practical purposes one Cubic Decimeter equals one Liter and one Liter of water weighs one Kilogram. The metric tables are formed by combining the words "Meter," "Gram," and "Liter" with the six numerical prefixes, as in the following tables:

| Prefixes. | Meaning. | | | Units. |
|---|---|---|---|---|
| milli- | = one thousandth | ..1/1000 | 0.001 | |
| centi- | = one hundredth | ..1/100 | 0.01 | "meter" for length |
| deci- | = one tenth. | ......1/10 | 0.1 | |
| Unit | = one. | ............ | 1. | "gram" for weight or mass |
| deka- | = ten | ............10/1 | 10. | |
| hecto- | = one hundred | ....100/1 | 100. | "liter" for capacity |
| kilo- | = one thousand | ...1000/1 | 1000. | |

All lengths, areas, and cubic measures in the following tables are derived from the international meter, the legal equivalent being 1 Meter = 39.37 Inches (law of July 28, 1866). In 1893 the United States Office of Standard Weights and Measures was authorized to derive the yard from the meter, using for the purpose the relation legalized in 1866, 1 Yard = 3600/3937 Meter.

The customary weights derived from the international kilogram are based on the value of 1 avoirdupois pound = 453.5924277 grams. This value is carried out farther than that given in the law, but is in accord with the latter as far as it is there given. The value of the troy pound is based upon the relation just mentioned and also the equivalent 5760/7000 avoirdupois pounds equal 1 troy pound.

In the following tables the metric unit has been selected as the common unit so that conversions may be made through the metric unit.

## LINEAR DIMENSIONS—CONVERSION FACTORS.

| Cm. to A. | A. | A. to Cm. |
|---|---|---|
| $1.0000 \cdot 10^{-5}$ | KILOMETER = 0.62137 — U. S. miles = 3280.83 ft. | $1.0000 \cdot 10^{5}$ |
| $1.0000 \cdot 10^{-2}$ (a) | METER = 3.28083 ft. = 39.37 inches (legal) | $1.0000 \cdot 10^{2}$ |
| 1.0000 | CENTIMETER = 0.3937 inch = 10 millimeters | 1.0000 |
| $1.0000 \cdot 10$ | MILLIMETER = 0.03937 inch = 1000 microns | $1.0000 \cdot 10^{-1}$ |
| $1.0000 \cdot 10^{4}$ | MICRON = 0.00003937 inch = 1000 millimicrons | $1.0000 \cdot 10^{-4}$ |
| $1.0000 \cdot 10^{7}$ | MILLIMICRON or MICROMILLIMETER = 10 A. U | $1.0000 \cdot 10^{-7}$ |
| $1.0000 \cdot 10^{8}$ | ANGSTROM UNIT = $3.932 \times 10^{-9}$ inch | $1.0000 \cdot 10^{-8}$ |
| $6.2137 \cdot 10^{-6}$ | MILE (Statute) = 5280 feet = 1.609347 kilom. | $1.6093 \cdot 10^{5}$ |
| $1.9883 \cdot 10^{-3}$ | ROD or PERCH = 16.5 feet | $5.029 \cdot 10^{2}$ |
| $1.0936 \cdot 10^{-2}$ | YARD = 3 feet | $9.144 \cdot 10$ |
| $3.28083 \cdot 10^{-2}$ | FOOT = 12 inches | $3.0480 \cdot 10$ |
| $3.937 \cdot 10^{-1}$ | INCH = 0.083333 ft. | 2.5400 |
| $3.937 \cdot 10^{2}$ | MIL = 1/1000 inch | $2.5400 \cdot 10^{-3}$ |
| $8.983 \cdot 10^{-8}$ | 1° LONGITUDE AT EQUATOR = 69.1713 Statute Miles | $1.1132 \cdot 10^{7}$ |
| $2.0712 \cdot 10^{-6}$ | LEAGUE = 3 Statute Miles | $4.8280 \cdot 10^{5}$ |
| $5.3959 \cdot 10^{-6}$ | KNOT, NAUTICAL MILE, SEA MILE = 6080.2 (Geographical Mile) | $1.85325 \cdot 10^{5}$ |
| $5.3957 \cdot 10^{-6}$ | BRITISH NAUTICAL MILE = 6080.4006466 + feet | $1.85319 \cdot 10^{5}$ |
| $4.97 \cdot 10^{-5}$ | FURLONG = 660 feet = 10 chains | $2.01168 \cdot 10^{4}$ |
| $2.7340 \cdot 10^{-4}$ | 1 CABLE LENGTH = 120 feet | $3.6576 \cdot 10^{3}$ |
| $5.468 \cdot 10^{-3}$ | U. S. FATHOM = 6 feet | $1.8288 \cdot 10^{2}$ |
| $4.9709 \cdot 10^{-4}$ | CHAIN = 66 feet = 100 links | $2.01168 \cdot 10^{3}$ |
| $4.97 \cdot 10^{-2}$ | LINK = 7.92 inches | $2.01168 \cdot 10$ |
| $1.118 \cdot 10^{-2}$ | VARA = 33⅓ inches | $8.4760 \cdot 10$ |
| $2.734 \cdot 10^{-4}$ | BOLT = 40 yards | $3.7576 \cdot 10^{3}$ |
| $1.1811 \cdot 10^{-1}$ | BARLEY CORN = ⅓ inch | 8.4667 |
| $4.3744 \cdot 10^{-2}$ | SPAN = 9 inches | $2.2860 \cdot 10$ |
| $9.8425 \cdot 10^{-2}$ | HAND = 4 inches | $1.0160 \cdot 10$ |
| $1.312 \cdot 10^{-1}$ | PALM = 3 inches | 7.6200 |
| 4.7244 | LINE = 1/12 inch | $2.1167 \cdot 10^{-1}$ |
| $2.834 \cdot 10$ | POINT = 1/72 inch | $3.5278 \cdot 10^{-2}$ |

(a) Note $10^{-5} = 1/10^{5} = 1/100000 = 0.00001$.

## SQUARE MEASURE, SURFACES, AREAS.

| Sq. em. to A. | A. | A. to sq. em. |
|---|---|---|
| $1.000 \cdot 10^{-8}$ | HECTARE = 2.471043930 acres | $1.000 \cdot 10^{8}$ |
| $1.000 \cdot 10^{-6}$ (a) | ARE or AR = 119.59852621 sq. yd | $1.000 \cdot 10^{6}$ |
| $1.000 \cdot 10^{-10}$ | SQUARE KILOMETER = 0.386100614 sq. miles | $1.000 \cdot 10^{10}$ |
| $1.000 \cdot 10^{-4}$ | SQUARE METER = 10.76386735908 sq. ft. | $1.000 \cdot 10^{4}$ |
| 1.000 | SQUARE CENTIMETER = 0.15499968997 sq. in. | 1.000 |
| $1.000 \cdot 10^{2}$ | SQUARE MILLIMETER = 0.001550 sq. in. | $1.000 \cdot 10^{-2}$ |
| $1.0725017 \cdot 10^{-12}$ | 1 TOWNSHIP = 36 square miles | $9.3239945 \cdot 10^{11}$ |
| $3.86100614 \cdot 10^{-11}$ | SQUARE MILE = 640 acres = $2.78784 \times 10^{7}$ sq. in. | $2.58999847 \cdot 10^{10}$ |
| $2.47104393 \cdot 10^{-8}$ | ACRE = 10 sq. chains = 43560 sq. ft. = 0.0015625 sq. mi. | $4.0468726 \cdot 10^{7}$ |
| $3.953670288 \cdot 10^{-6}$ | SQ. ROD or POLE = 272.25 sq. ft. = 0.00625 A | $2.52929537 \cdot 10^{5}$ |
| $1.19598526 \cdot 10^{-4}$ | SQUARE YARD = 9 sq. ft. = 1296 sq. in. | $8.3613 \cdot 10^{3}$ |
| $1.0763867359 \cdot 10^{-3}$ | SQUARE FOOT = 144 sq. in. = $3.58701 \times 10^{-8}$ sq. mi. | $9.29034 \cdot 10^{2}$ |
| $1.5499968 \cdot 10^{-1}$ | SQUARE INCH = 0.0069444 sq. ft. = $2.491 \times 10^{-10}$ sq. mi. | 6.4516 |
| $1.5499968 \cdot 10^{5}$ | SQUARE MIL = 0.000001 sq. in. | $6.4516 \cdot 10^{-6}$ |
| $1.2705 \cdot 10^{5}$ | CIRCULAR MIL = (wire) = 0.00000122 sq. in. | $7.871 \cdot 10^{-6}$ |
| $2.47104393 \cdot 10^{-7}$ | SQUARE CHAIN = 4356 sq. ft. = 0.1 acres | $4.0468726 \cdot 10^{6}$ |
| $2.47104393 \cdot 10^{-4}$ | SQUARE LINK = 62.7264 sq. in. = 0.4356 sq. ft. | $4.0468726 \cdot 10^{3}$ |
| $1.0764 \cdot 10^{-5}$ | 1 SQUARE (roofs and floors) = 100 sq. ft. | $9.29034 \cdot 10^{4}$ |

(a) $10^{-8} = 1/10^{8} = 1/100000000 = 0.00000001$

## VOLUME, CAPACITY, CUBIC CONTENTS, SPACE.

| Cubic centimeter to A. | A. | A. to cubic centimeter. |
|---|---|---|
| 1.000 | CUBIC CENTIMETER = 16.23 minims = 0.0610 cu. in. | 1.0000 |
| $1.000 \cdot 10^{-3}$ | LITER = 1.056681868 U. S. Qt. = 61.023 cu. in. | $1.000 \cdot 10^{3}$ |
| $1.000 \cdot 10^{-6}$ | CUBIC METER = 264.4 U. S. Gal. = 35.3165 cu. ft. (Kiloliter) (stere) = 1.307942772 cu. yd. | $1.000 \cdot 10^{6}$ |
| $6.1023377953 \cdot 10^{-2}$ | CUBIC INCH = 0.553 fld. oz. = 0.00058 cu. ft. | $1.6387 \cdot 10$ |
| $3.532 \cdot 10^{-5}$ | CUBIC FOOT = 7.48 U. S. Gal. = 1728 cu. in. | $2.8317 \cdot 10^{4}$ |
| $1.308 \cdot 10^{-9}$ | CUBIC YARD = 20.197 U. S. Gal. = 27 cu. ft. | $7.64559 \cdot 10^{5}$ |

## U. S. LIQUID AND APOTHECARY MEASURE.

| | | |
|---|---|---|
| $1.623 \cdot 10$ | MINIM = about 1 drop = 0.00376 cu. in. | $6.16119 \cdot 10^{-2}$ |
| $2.705 \cdot 10^{-1}$ | FLUID DRAM = 60 minims = 0.2256 cu. in. | $3.6967$ |
| $8.116 \cdot 10^{-1}$ | SCRUPLE = 20 minims = 0.0752 cu. in. | $1.2322$ |
| $3.3815 \cdot 10^{-2}$ | FLUID OUNCE = 8 drams = 1.805 cu. in. | $2.9573 \cdot 10$ |
| $8.454 \cdot 10^{-3}$ | GILL = 4 ounces = 7.220 cu. in. | $1.1829 \cdot 10^{2}$ |
| $2.113 \cdot 10^{-3}$ | PINT = 16 ounces = 28.88 cu. in. | $4.73179 \cdot 10^{2}$ |
| $1.056 \cdot 10^{-3}$ | QUART = 2 pints = 57.76 cu. in. | $9.46358 \cdot 10^{2}$ |
| $2.641704673 \cdot 10^{-4}$ | GALLON = 4 quarts = 0.1337 cu. ft. = 231 cu. in. | $3.78543 \cdot 10^{3}$ |
| $8.387 \cdot 10^{-6}$ | BARREL (wine) = 31½ gallons = 4.205 cu. ft. | $1.1924 \cdot 10^{5}$ |
| $4.193 \cdot 10^{-6}$ | HOGSHEAD = 63 gallons = 8.410 cu. ft. | $2.3848 \cdot 10^{5}$ |
| $6.297 \cdot 10^{-6}$ | BARREL (petroleum) = 42 gal. = 5.615 cu. ft. | $1.58984 \cdot 10^{5}$ |
| $6.297 \cdot 10^{-6}$ | TIERCE = 42 gal. = 5.615 cu. ft. | $1.5898 \cdot 10^{5}$ |
| $3.148 \cdot 10^{-6}$ | PUNCHEON = 84 gallons = 11.23 cu. ft. | $3.176 \cdot 10^{5}$ |

## U. S. DRY MEASURE.

| Cubic centimeter to A. | A. | A. to cubic centimeter. |
|---|---|---|
| $1.816 \cdot 10^{-3}$ | PINT = 33.6 cu. in. | $5.506 \cdot 10^{2}$ |
| $9.08 \cdot 10^{-4}$ | QUART = 1.101 liters = 67.2 cu. in. | $1.10123 \cdot 10^{3}$ |
| $2.27 \cdot 10^{-4}$ | GALLON = 4.4049 liters = 268.8 cu. in. | $4.40492 \cdot 10^{3}$ |
| $1.13 \cdot 10^{-4}$ | PECK = 8.8098 liters = 537.6 cu. in. | $8.80984 \cdot 10^{3}$ |
| $2.837742299 \cdot 10^{-5}$ | BUSHEL = 9.31 U. S. Gal. = 2150.4 cu. in. | $3.523928 \cdot 10^{4}$ |
| $9.418 \cdot 10^{-6}$ | BARREL (flour) 196 lbs. = 88.904 kgm. = 7056 cu. in. = 408 cu. ft. | $1.06180 \cdot 10^{5}$ |
| $8.849 \cdot 10^{-5}$ | BARREL (cement) = 376 lbs. = 170.551 kgm. = 4.0 cu. ft. | $1.13 \cdot 10^{5}$ |

## BRITISH LIQUID AND DRY MEASURE.

| | | |
|---|---|---|
| $1.693 \cdot 10$ | MINIMS = about 1 drop = 0.00361 cu. in. | $5.9192 \cdot 10^{-2}$ |
| $2.8219 \cdot 10^{-1}$ | DRACHM = 60 minims = 0.2166 cu. in. | $3.54958$ |
| $3.527 \cdot 10^{-2}$ | OUNCE = 8 drachms = 1.733 cu. in. | $2.839661 \cdot 10$ |
| $1.7608 \cdot 10^{-3}$ | PINT = 20 ounces = 34.67 cu. in. | $5.6793 \cdot 10^{2}$ |
| $8.804 \cdot 10^{-4}$ | QUART = 1.136 liters = 69.34 cu. in. | $1.13586 \cdot 10^{3}$ |
| $2.201 \cdot 10^{-4}$ | GALLON = 4.543 liters = 277.274 cu. in. | $4.54345797 \cdot 10^{3}$ |
| $1.1005 \cdot 10^{-4}$ | PECK = 2 gallons = 554.4 cu. in. | $9.08692 \cdot 10^{3}$ |
| $2.75121 \cdot 10^{-5}$ | BUSHEL = 8 gallons = 2218.2 cu. in. | $3.63477 \cdot 10^{4}$ |
| $6.87802 \cdot 10^{-6}$ | COOMB = 4 bushels = 5.1347 cu. ft. | $1.453908 \cdot 10^{5}$ |
| $3.43901 \cdot 10^{-6}$ | QUARTER = 8 bushels = 10.269 cu. ft. | $2.907816 \cdot 10^{5}$ |

## MISCELLANEOUS.

| | | |
|---|---|---|
| $5.085 \cdot 10^{-3}$ | BOARD FOOT $(1' \times 1' \times 1'')$ = 144 cu. in. | $1.96642 \cdot 10^{2}$ |
| $2.760 \cdot 10^{-7}$ | CORD $(4' \times 4' \times 8')$ = 128 cu. ft. | $3.6246 \cdot 10^{6}$ |
| $8.1034 \cdot 10^{-10}$ | ACRE FOOT = 362000 U. S. Gal. = 43560 cu. ft. | $1.2335 \cdot 10^{9}$ |
| $8.88 \cdot 10^{-7}$ | U. S. SHIPPING TON = 40 cu. ft. | $1.13268 \cdot 10^{6}$ |
| $8.409 \cdot 10^{-7}$ | 1 BRITISH SHIPPING TON = 42 cu. ft. | $1.1893 \cdot 10^{6}$ |

U. S. liquid measure $\times$ 1.2003 = British liquid and dry of same denomination.
U. S. dry measure $\times$ 1.032 = British liquid and dry of same denomination.

## WEIGHTS—CONVERSION FACTORS.

| Grams to A. | A. | A. to grams. |
|---|---|---|
| 1.000 | GRAM (1 cc. water at 4°C.) = 15.432 grains | 1.0000 |
| $1.000 \cdot 10^3$ | MILLIGRAM = 0.015432 grain | $1.0000 \cdot 10^{-3}$ |
| $1.0000 \cdot 10^{-3}$ | KILOGRAM = 2.679 T. lbs. = 2.204622341 Av. lbs. | $1.0000 \cdot 10^3$ |
| $1.000 \cdot 10^{-5}$ (*a*) | QUINTAL (100 kilograms) = 2.2046 cwt. | $1.0000 \cdot 10^5$ |
| $1.000 \cdot 10^{-6}$ | METRIC TON = 1.1023 ton (short) = 2204.6 lbs. | $1.0000 \cdot 10^6$ |
| $1.5432 \cdot 10$ | GRAIN (T. Ap. Av.) = 0.0020835 ounce (T.) | $6.4799 \cdot 10^{-2}$ |
| $6.430 \cdot 10^{-1}$ | PENNYWEIGHT (T.) = 24.0 grains | 1.5552 |
| $6.43 \cdot 10^{-2}$ | CARET (T.) = 10.0 pwt. | $1.5552 \cdot 10$ |
| $7.716 \cdot 10$ | SCRUPLE (Ap.) = 20.0 grains | 1.2960 |
| $2.572 \cdot 10$ | DRAM (Ap.) = 60.0 grains | 3.8879 |
| $3.215 \cdot 10^{-2}$ | OUNCE (T.) = 1.09714 + oz. Av. = 480 grains | 31.1035 |
| $2.68 \cdot 10^{-3}$ | POUND (T.) = 0.822857 lb. Av. = 12 oz. Troy | $3.732714662 \cdot 10^2$ |
| $3.5273990 \cdot 10^{-2}$ | OUNCE (Av.) = 0.911450 oz. T. = 437.5 grains | $2.834952673 \cdot 10$ |
| $2.2046244 \cdot 10^{-3}$ | POUND (Av.) = 1.2153 lbs. T. = 16 oz. Av. = 7000 grains | $4.535924277 \cdot 10^2$ |
| $2.2046244 \cdot 10^{-5}$ | HUNDRED WEIGHT (short) = 100 lbs. | $4.5359 \cdot 10^4$ |
| $1.968414 \cdot 10^{-5}$ | HUNDRED WEIGHT (long) = 112 lbs. | $5.0802 \cdot 10^4$ |
| $1.1023122 \cdot 10^{-6}$ | TON (U. S. short) = 2000 lbs. | $9.07184 \cdot 10^5$ |
| $0.9845 \cdot 10^{-6}$ | TON (British long) = 2240 lbs. | $1.016 \cdot 10^6$ |
| $3.937 \cdot 10^{-5}$ | STONE = 14 lbs. | $6.3503 \cdot 10^3$ |
| $7.874 \cdot 10^{-5}$ | QUARTER = 25 lbs. | $1.13368 \cdot 10^4$ |
| 4.8665 | CARAT (precious stones) = 3.1713 grains | $2.055 \cdot 10^{-1}$ |
| 0.03429 | ASSAY TON (metallurgists) = oz. Av. = 0.885188 oz. Troy | $2.91667 \cdot 10$ |

T. = Troy. Ap. = Apothecary. Av. = Avoirdupois.

(*a*) $10^{-3} = 1/10^3 = 1/1000 = 0.001$.

## WORK CONVERSIONS.

| | 1. Erg.* | 2. Joule. | 3. Kilojoule. | 4. Watt hour. | 5. K. W. hour. | 6. H. P. hour. |
|---|---|---|---|---|---|---|
| 1. Erg | 1.0000 | $10^{-7}$ (a) | $1.000 \cdot 10^{-10}$ | $2.778 \cdot 10^{-11}$ | $2.778 \cdot 10^{-14}$ | $3.725 \cdot 10^{-14}$ |
| 2. Joule | $10^{7}$ | 1.0000 | $10^{-3}$ | $2.778 . 10^{-4}$ | $2.778 . 10^{-7}$ | $3.725 \cdot 10^{-7}$ |
| 3. Kilojoule | $10^{10}$ | $10^{3}$ | 1.0000 | $2.778 . 10^{-1}$ | $2.778 \cdot 10^{-4}$ | $3.725 \cdot 10^{-4}$ |
| 4. Watt hour | $3.6 \cdot 10^{10}$ | 3600.00 | 3.600 | 1.000 | $1.000 \cdot 10^{-3}$ | $1.341 \cdot 10^{-3}$ |
| 5. Kilowatt hr | $3.6 . 10^{13}$ | $3.6 \cdot 10^{6}$ | 3600.000 | 1000.000 | 1.000 | 1.3411128 |
| 6. Horse-power hr | $2.684 \cdot 10^{13}$ | $2.684 \cdot 10^{6}$ | $2.684 \cdot 10^{3}$ | 745.6494 | 0.7456494 | 1.0000 |
| 7. Foot pound | $1.3544 \cdot 10^{7}$ | 1.3544 | $1.3544 \cdot 10^{-3}$ | $3.762 \cdot 10^{-4}$ | $3.762 \cdot 10^{-7}$ | $5.046 \cdot 10^{7}$ |
| 8. Caloric (gm.) | $4.189 \cdot 10^{7}$ | 4.189 | $4.189 \cdot 10^{-3}$ | $1.163 \cdot 10^{-3}$ | $1.163 \cdot 10^{-6}$ | $1.500 \cdot 10^{-6}$ |
| 9. Brit. Thermal Units | $1.0553 . 10^{10}$ | 1055.3 | 1.0553 | $2.931 \cdot 10^{-1}$ | $2.931 \cdot 10^{-4}$ | $3.931 \cdot 10^{-4}$ |
| 10. Cu. ft. water fall— 1 ft. (4°C.) | 8.463 | 84.63 | 0.08463 | $2.351 \cdot 10^{-2}$ | $2.351 \cdot 10^{-5}$ | $3.153 . 10^{-5}$ |
| 11. Kilogram-meter | $9.8062 \cdot 10^{7}$ | 9.8062 | $9.8062 . 10^{-3}$ | $2.724 \cdot 10^{-3}$ | $2.724 . 10^{-6}$ | $3.653 \cdot 10^{-6}$ |

*The work done by one dyne acting through one centimeter is an erg.
(a) $10^{7} = 1/10^{7} = 1/10{,}000{,}000 = 0.0000001$.

| | 7. Foot Lb. | 8. Calorie (15°C). | 9. B. T. U. | 10. Cu. ft. $H_2O$ 1 ft. | 11. Kgm. meter |
|---|---|---|---|---|---|
| 1. Erg | $7.384 \cdot 10^{-8}$ | $2.387 \cdot 10^{-8}$ | $9.476 \cdot 10^{-11}$ | $1.1812 \cdot 10^{-9}$ | $1.0197 \cdot 10^{-8}$ |
| 2. Joule | $7.384 \cdot 10^{-1}$ | $2.387 \cdot 10^{-1}$ | $9.476 . 10^{-4}$ | $1.1812 \cdot 10^{-2}$ | $1.0197 \cdot 10^{-1}$ |
| 3. Kilojoule | $7.384 \cdot 10^{2}$ | $2.387 \cdot 10^{2}$ | $9.476 \cdot 10^{-1}$ | $1.1812 \cdot 10$ | $1.0197 \cdot 10^{2}$ |
| 4. Watt hour | $2.658 \cdot 10^{3}$ | $8.594 . 10^{8}$ | 3.4115 | $4.2525 \cdot 10$ | $3.671 . 10^{2}$ |
| 5. K. W. hr | $2.658 . 10^{-6}$ | $8.594 \cdot 10^{5}$ | $3.411 \cdot 10^{3}$ | $4.2525 \cdot 10^{4}$ | $3.671 \cdot 10^{5}$ |
| 6. H. P. hr | $1.982 \cdot 10^{6}$ | $6.407 \cdot 10^{5}$ | $2.543 \cdot 10^{3}$ | $3.170 \cdot 10^{4}$ | $2.737 \cdot 10^{5}$ |
| 7. Ft. pound | 1.000 | $3.233 \cdot 10^{-1}$ | $1.2835 \cdot 10^{-3}$ | $1.600 . 10^{-2}$ | $1.381 \cdot 10^{-1}$ |
| 8. Calorie | 3.093 | 1.0000 | $3.969 \cdot 10^{-3}$ | $4.948 \cdot 10^{-2}$ | $4.272 \cdot 10^{-1}$ |
| 9. B. T. U. | $7.794 \cdot 10^{2}$ | $2.520 \cdot 10^{2}$ | 1.000 | $1.247 \cdot 10$ | $1.076 \cdot 10^{9}$ |
| 10. Cu. ft. $H_2O$ 1 ft. | $6.250 \cdot 10$ | $2.021 \cdot 10$ | $8.022 \cdot 10^{-2}$ | 1.0000 | 8.630 |
| 11. Kgm.-meter | 7.241 | 2.341 | $9.292 . 10^{-3}$ | $1.1582 \cdot 10^{-1}$ | 1.0000 |

## PRESSURE CONVERSIONS.

| | 1. Cm. $H_2O$. | 2. In $H_2O$. | 3. Ft. $H_2O$. | 4. Mm. Hg. | 5. Cm. Hg. | 6. In Hg. |
|---|---|---|---|---|---|---|
| 1. Cm. water 4° C.... | 1.0000 | 0.3937 | 0.03281 | 0.7356 | 0.07356 | 0.02896 |
| 2. Inches of water... | 2.540 | 1.0000 | 0.08333 | 1.8685 | 0.18685 | 0.07356 |
| 3. Feet of water..... | 30.48 | 12.00 | 1.0000 | 22.42 | 2.242 | 0.8826 |
| 4. Mm. of mercury... | 1.3595 | 0.5353 | 0.4461 | 1.0000 | 0.10000 | 0.03937 |
| 5. Cm. of mercury... | 13.595 | 5.353 | 4.461 | 10.00 | 1.0000 | 0.39370 |
| 6. In. of mercury.... | 34.54 | 13.595 | 1.1330 | 25.40 | 2.540 | 1.0000 |
| 7. Gm. per sq. cm.... | 1.000 | 0.3937 | 0.03281 | 0.7356 | 0.07356 | 0.02896 |
| 8. Kg. per sq. cm.... | 1000.0000 | 393.7 | 32.81 | 735.6 | 73.56 | 28.96 |
| 9. Oz. per sq. in..... | 4.394 | 1.7300 | 0.14416 | 3.232 | 0.3232 | 0.12725 |
| 10. Lbs. per sq. in..... | 70.32 | 27.68 | 2.307 | 5.171 | 0.5171 | 2.036 |
| 11. Oz. per sq. ft..... | 0.03052 | 0.012012 | 0.0010012 | 0.02245 | $2.245 \cdot 10^{-3}$ | $8.836 \cdot 10^{-4}$ |
| 12. Lbs. per sq. ft..... | 0.4885 | 0.1923 | 0.01602 | 0.3591 | 0.03591 | 0.014137 |
| 13. Dynes per sq. cm.. | $1.0197 \cdot 10^{-3}$ | $4.0145 \cdot 10^{-4}$ | $3.3455 \cdot 10^{-5}$ | $7.500 \cdot 10^{-4}$ | $7.500 \cdot 10^{-5}$ | $2.952 \cdot 10^{-5}$ |
| 14. Atmospheres* .... | 1033.29 | 406.806 | 33.9005 | 760.00 | 76.000 | 29.9212 |

Mercury at 0° C. Water at 4° C.

*Atmosphere is the pressure exerted by a column of mercury 76.0 cm. high at 0° C. at sea level and in a latitude of 45° upon the area of one square centimeter.

## PRESSURE CONVERSIONS—Continued.

| | 7. Gms/cm.$^2$ | 8. Kgm./gm$^2$. | 9. Oz./in$^2$. | 10. Lbs./in$^2$. | 11. Oz./ft$^2$. | 12. Lbs./ft$^2$. | 13. Dynes/cm$^2$. | 14. Atmospheres. |
|---|---|---|---|---|---|---|---|---|
| 1........ | 1.0000 | 0.001000 | 0.2276 | 0.01422 | 32.77 | 2.048 | 980.62 | $9.679 \cdot 10^{-4}$ |
| 2........ | 2.540 | 0.002540 | 0.5780 | 0.036125 | 83.23 | 5.205 | 2492.0 | 0.002458 |
| 3........ | 30.48 | 0.03048 | 6.937 | 0.4335 | 998.8 | 62.43 | 29890.0 | 0.02950 |
| 4........ | 1.3595 | 0.0013595 | 0.3094 | 0.01934 | 44.56 | 2.785 | 1333.3 | 0.0013159 |
| 5........ | 13.595 | 0.013595 | 3.094 | 0.1934 | 445.6 | 27.85 | 13333.0 | 0.013159 |
| 6........ | 34.54 | 0.03454 | 7.860 | 0.4912 | 1131.7 | 70.73 | 33865.0 | 0.03342 |
| 7........ | 1.000 | 0.001 | 0.2276 | 0.014223 | 32.770 | 2.048 | 980.62 | $9.679 \cdot 10^{-4}$ |
| 8........ | 1000.0 | 1.0000 | 227.6 | 14.223 | 32770.0 | 2048.0 | 980620.0 | 0.9679 |
| 9........ | 4.394 | $4.394 \cdot 10^{-3}$ | 1.0000 | 0.06250 | 144.0 | 9.000 | 4309.5 | 0.0042525 |
| 10........ | 70.32 | 0.07032 | 16.000 | 1.0000 | 2304.2 | 144.00 | 68950.0 | 0.06805 |
| 11........ | 0.03052 | $3.052 \cdot 10^{-5}$ | $6.946 \cdot 10^{-3}$ | $4.340 \cdot 10^{-4}$ | 1.0000 | 0.06250 | 29.93 | $2.9533 . 10^{-5}$ |
| 12........ | 0.4885 | $4.885 \cdot 10^{-4}$ | 0.11112 | 0.006944 | 16.000 | 1.000 | 478.9 | $4.725 \cdot 10^{-4}$ |
| 13........ | $1.0197 \cdot 10^{-3}$ | $1.019 \cdot 10^{-6}$ | $2.3208 \cdot 10^{-4}$ | $1.4504\ 10^{-5}$ | $3.3410 \cdot 10^{-2}$ | $2.088 \cdot 10^{-3}$ | 1.0 | $9.868 \cdot 10^{-7}$ |
| 14........ | 1033.29 | 1.03329 | 235.152 | 14.697 | 33861.9 | 2116.37 | 1013295.0 | 1.00000 |

## COMPARATIVE TEMPERATURE DEGREES.

| | Degrees Absolute | Degrees Cent. | Degrees Fahr. | Degrees Reaumur. |
|---|---|---|---|---|
| Degrees Absolute................ | 1.0 | 1.0 | 9/5 | 4/5 |
| Degrees Centigrade.............. | 1.0 | 1.0 | 9/5 | 4/5 |
| Degrees Fahrenheit.............. | 5/9 | 5/9 | 1.0 | 4/9 |
| Degrees Reaumur................. | 5/4 | 5/4 | 9/4 | 1.0 |

## COMPARATIVE TEMPERATURE POINTS.

Absolute zero = —273° Centigrade = —459.4° Fahr. = —218.4° Reaum.
Freezing water = 0° C. = 273° A. = 32° F. = 0° R.
Boiling water = 100° C. = 373° A. = 212° F. = 80° R.

## HEAT QUANTITY CONVERSION FACTORS.

One British Thermal Unit = 251.995 × calories (gm.) = 0.251995 × Cal. Large.
One gram caloric = 0.00396832 British Thermal Units.
One B. T. U. per pound = 5/9 calorie per gram.
One calorie per gram = 1.8 B. T. U. per pound.

## TIME CONVERSION FACTORS.

One year = 365 days, 5 hours, 48 minutes, 48 seconds = 12 calendar months.
= 52.1693 + weeks = 8765.8133 + hrs. = 525948.8 minutes = 31556928 seconds.
One week 7 days = 168 hrs. = 10080 minutes = 604800 seconds.
One day = 24 hours = 1440 minutes = 86400 seconds.
One hour = 60 minutes = 3600 seconds.
One minute = 60 seconds.

## VELOCITY CONVERSION FACTORS.

| | Mi./hr. 1. | Ft./sec. 2. | Km./hr. 3. | M/sec. 4. | Mi./da. 5. | Km./da. 6. |
|---|---|---|---|---|---|---|
| 1. Miles per hour... | 1.0000 | 1.4667 | 1.6093 | 0.44704 | 24.00 | 38.62 |
| 2. Feet per second... | 0.6819 | 1.0000 | 1.0973 | 0.30480 | 16.37 | 26.33 |
| 3. Kilometers/hour . | 0.6214 | 0.9114 | 1.0000 | 0.2778 | 14.913 | 24.00 |
| 4. Meters per second. | 2.237 | 3.281 | 3.600 | 1.0000 | 53.69 | 86.40 |
| 5. Miles per day.... | 0.04167 | 0.06112 | 0.06706 | 0.01863 | 1.0000 | 1.609 |
| 6. Kilometers/day .. | 0.02589 | 0.03797 | 0.04167 | 0.01157 | 0.6214 | 1.0000 |

## CONVERSION FACTORS FOR MONEY.

| $ to A. | A. | | A. to $. |
|---|---|---|---|
| 1.000 | Dollar (U. S.) | | 1.000 |
| 100.000 | Cent (U. S.) | | 0.010 |
| 0.196 | Guinea (English) | = 21 shillings | 5.10972 |
| 0.2055 | Pound Sterling (Sovereign) | = 20 shillings | 4.8665 |
| 4.11 | Shilling (s) | = 12 pence | 0.24331 |
| 40.93 | Penny (d) | = 4 farthings | 0.02028 |
| 163.72 | Farthing | = ¼ penny | 0.00507 |
| 0.822 | Crown | = 5 shillings | 1.21660 |
| 4.200 | Mark (Germany) | = 100 pfennigs | 0.238 |
| 420.0 | Pfennig | | 0.00238 |
| 5.182 | Franc (France) | = 100 centimes | 0.193 |
| 518.2 | Centime | | 0.00193 |

## CLASSIFICATION OF U. S. PATENTS ON PETROLEUM REFINING.

A. Water separation, dehydration, de-emulsification, heating and physical purification of oil and bottom settlings.
B. Cracking, conversion, and decomposition processes.
C. Paraffin and wax.
D. Chemical treatment of petroleum.
  1. Acid or alkali.
  2. Other than acid or alkali.
E. Asphalt.
  1. Compositions.
  2. Production.
  3. Refining.
F. Simple distillation.
  1. Fire.
  2. Steam.
  3. Gas.
  4. Air.
  5. Vacuum.
    I. Batch.
    II. Continuous.
G. Coal oil, Kerosene and Illuminating oils.
H. Oil-fire prevention, extinction and storage.
I. Recovery of acid-sludge and alkali-sludge.
J. Gasoline production and treatment.
K. Gas.
  1. Production.
  2. Treatment.
  3. Production of carbon black.
L. Chemical products.
M. Patented blends and compounds.
N. Testing apparatus.
O. Lubricating oils.
P. Electrical processes.
Q. Transporting oil.
R. Methods of removing carbon and coke.
S. Mechanical appliances in oil refining, and processes. (Not covering any particular operation.)
T. Plastics.
U. Condensers and condensing.
V. Desulphurizing and deodorizing.
W. Oil shales, oil sands and coals.

## UNITED STATES PETROLEUM PATENTS.

| Name | Number | Date | Class |
|---|---|---|---|
| Aab., Geo. & S. K. Campbell | 369,902 | Sept. 13, 1887 | C |
| Adair, James. | 35,497 | June 10, 1862 | U |
| Adair, Jas. & Tweddle, H. W. C. | 56,343 | July 17, 1866 | F |
| Adair, Thos. D. | 1,106,352 | Aug. 4, 1914 | A |
| Adams, Chas. | 52,509 | Feb. 13, 1866 | C |
| Adams, J. H. | 976,975 | Nov. 29, 1910 | B |
| Adams, Henry W. | 12,614 | Apr. 3, 1855 | O |
| Adamson, Wm. | 45,007 | Nov. 15, 1864 | D 1 |
| Adiassewich, Alexander | 629,536 | July 25, 1899 | F |
| Alberger, J. L. | 37,798 | Mar. 3, 1863 | G, B |
| Alexander, Clive M. | 1,230,975 | June 26, 1917 | B |
| Alexander, Jas. H. | 229,297 | June 29, 1880 | F |
| Alexander, Jas. H. & Eberhard | 156,265 | Oct. 27, 1874 | F |
| Alexander, Robt. | 435,198 | Aug. 26, 1890 | E 3 |
| Alkemade, J. von R. | 1,007,600 | Oct. 14, 1913 | C |
| Allen, George. | 182,625 | Sept. 26, 1876 | A, O |
| Allan, D. M., Jr. | 1,187,979 | June 20, 1916 | D 1 |
| Alter, David & Hill, S. A. | 20,026 | Apr. 27, 1858 | F |
| Alvord, Clark. | 213,157 | Mar. 11, 1879 | R |
| Ambruson, H. J. | 1,252,642 | Jan. 8, 1918 | K 1 |
| Amend, Otto P. | 747,348 | Dec. 22, 1903 | D 1, V |
| Amend, Otto P. | 480,312 | Aug. 9, 1892 | V, D 1, B |
| Amend, Otto P. | 480,311 | Aug. 9, 1892 | V, D 1, B |
| Amend, Otto P. | 551,941 | Dec. 24, 1895 | V, D 1 |
| Amend, Otto P. | 601,331 | Mar. 29, 1898 | V, D 1 |
| Amend, Otto P. | 747,347 | Dec. 22, 1903 | V, D 1 |
| Andrews, Saml. | 58,197 | Sept. 25, 1866 | F 1, I |
| Andrews, Saml. | 69,745 | Oct. 15, 1867 | S |
| Angus, H. R. | 407,274 | July 16, 1880 | F |
| Anthony, C. E. | 620,082 | Feb. 21, 1899 | B, T |
| Archbold, Geo. | 503,028 | Aug. 8, 1893 | E 1 |
| Archer, Wm. | 44,137 | Sept. 6, 1864 | F |
| Artmann, Carl. | 1,031,227 | July 2, 1912 | E 1 |
| Arvine, Freeling W. | 629,059 | July 18, 1899 | A |
| Arvine, Freeling W. | 431,795 | July 8, 1890 | G, N |
| Ash, Horace W. | 779,197 | Jan. 3, 1905 | E 2, F |
| Ash, Horace W. | 779,198 | Jan. 3, 1905 | E 2, F |
| Ash, Horace W. | 757,387 | Apr. 12, 1904 | F 1 |
| Ashworth, A. A. | 1,300,548 | Apr. 15, 1919 | S |
| Andrews and Averill | 1,312,467 | Apr. 10, 1860 | S |
| Atwood, Luther. | 27,767 | Oct. 19, 1858 | F 2 |
| Atwood, Luther. | 21,805 | Dec. 28, 1858 | B |
| Atwood, Luther. | 22,406 | Dec. 28, 1858 | B |
| Atwood, Luther. | 22,407 | Feb. 22, 1859 | B |
| Atwood, Luther. | 23,006 | Mar. 29, 1859 | B |
| Atwood, Luther. | 23,337 | May 15, 1860 | G |
| Atwood, Luther. | 28,246 | May 29, 1860 | G, B |
| Atwood, Luther. | 28,448 | Apr. 10, 1860 | F |
| Atwood, Luther. | 27,768 | Mar. 26, 1861 | U |
| Atwood, Luther. | 31,858 | Aug. 12, 1856 | B,2D 1 |
| Atwood, L. & Atwood, W. | 15,506 | Aug. 12, 1856 | W, F |
| Atwood, L. & Atwood, W. | 15,505 | Apr. 6, 1880 | G |
| Atwood, William. | 226,151 | Apr. 20, 1901 | A |
| Aukerman, Cal. M. | 572,882 | Aug. 5, 1919 | B |
| Bacon, Brooks & Clark | 1,131,309 | Mar. 9, 1915 | J, B |
| Bacon & Clark | 1,101,482 | June 23, 1914 | B |
| Backhaus, Arthur A. | 1,271,114 | July 2, 1918 | M |
| Backhaus, Arthur A. | 1,271,115 | July 2, 1918 | M |
| Backhaus, A. A. | 1,296,902 | Mar. 11, 1919 | M |
| Barber, Guy M. | 1,251,952 | Jan. 1, 1918 | S |
| Baillard, Chas. L. | 340,411 | Apr. 20, 1886 | D 1 |
| Baker, Leslie A. | 299,611 | June 3, 1884 | A |
| Barnes, Wm. T. | 24,920 | Aug. 2, 1859 | U |
| Barnes, Wm. T. | 24,921 | Aug. 2, 1859 | G |
| Barrett, Michael. | 59,531 | Nov. 6, 1866 | I |
| Barron, Thos. J. | 46,987 | Mar. 28, 1865 | M |
| Barnickel, W. S. | 1,093,098 | Apr. 14, 1914 | A, D 1 |
| Barnickel, W. S. | 1,223,659 | Apr. 24, 1917 | A, D 1 |
| Barnickel, W. S. | 1,223,660 | Apr. 24, 1917 | A |
| Bartels, E. | 1,115,887 | Nov. 3, 1914 | H |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Barstow, Frank Q. | 181,814 | Sept. 5, 1876 | C |
| Barthel, Peter. | 135,879 | Feb. 18, 1873 | E 1, 8 |
| Baskerville, Chas. | 1,231,985 | July 3, 1917 | I |
| Bassett, R. D. | 1,120,669 | Dec. 15, 1914 | J |
| Bassett, R. D. | 1,120,670 | Dec. 15, 1914 | J |
| Bates, H. F. | 1,046,541 | Dec. 10, 1912 | K 1 |
| Baum, E. P. | 1,109,103 | Sept. 1, 1914 | A |
| Baynes, R. & Fearenside, J. | 299,324 | May 27, 1884 | D 2 |
| Bell, A. F. L. | 581,451 | Apr. 27, 1897 | E 3, 2 |
| Bell, A. F. L. | 581,592 | Apr. 13, 1897 | E 3 |
| Bell, A. F. L. | 617,712 | Jan. 17, 1899 | E 2, 3 |
| Bell, A. F. L. | 1,231,695 | July 3, 1917 | B, R |
| Bell, A. F. L. | 655,430 | Aug. 7, 1900 | E 2, 3 |
| Bell, A. F. L. | 505,416 | Sept. 19, 1893 | E 2, 3 |
| Bellingrath, Leonard, Jr. | 20,465 | June 1, 1858 | F 1, 4 |
| Bending, Wm. P. | 998,670 | July 25, 1911 | A |
| Benham, E. B. | 1,262,576 | Apr. 9, 1918 | K 1 |
| Berg, Friedrich. | 645,743 | Mar. 20, 1900 | F 2, 1 |
| Berg, Friedrich. | 560,463 | May 19, 1896 | D 1 |
| Berg, F. | 736,479 | Aug. 18, 1903 | V, D 1 |
| Berg, F. | 736,480 | Aug. 18, 1903 | V |
| Berg, F. | 623,066 | Apr. 11, 1890 | D 1 |
| Berg, H. J. | 93,952 | Aug. 24, 1869 | F 1, 11 |
| Bibby, John & Lapham, A. | 48,896 | July 25, 1865 | F 1 |
| Bicknell, John E. | 313,979 | Mar. 17, 1885 | F 2 |
| Bicknell, John E. | 400,042 | Mar. 26, 1889 | C |
| Bicknell, John E. | 400,043 | Mar. 26, 1889 | C |
| Birge, Wm. H. | 175,014 | Mar. 21, 1876 | F 2 |
| Blackmore, H. S. | 486,554 | Nov. 22, 1892 | U |
| Blackmore, H. S. | 793,026 | June 20, 1905 | V, D 1 |
| Blair, John B. | 139,654 | June 10, 1873 | N |
| Bloede, Victor G. | 159,887 | Feb. 16, 1875 | F |
| Blumenthal, Leon. | 312,605 | Feb. 24, 1885 | G |
| Boleg, Friedrich. | 761,939 | June 7, 1904 | M |
| Boote, A. J. & Kittredge, H. G. | 620,882 | Mar. 14, 1899 | V, D 1 |
| Bower, Henry. | 230,171 | July 20, 1880 | I |
| Beckley, R. E. | 1,127,722 | Feb. 9, 1915 | B |
| Bending, Wm. P. | 1,144,522 | June 29, 1915 | D 1 |
| Benham, E. B. | 1,040,124 | Oct. 1, 1912 | B |
| Butcher, J. A. | 1,311,753 | July 29, 1919 | H |
| Benhoff, Geo. F., Jr., & Jensen, J. O. | 1,181,564 | May 2, 1916 | F 2 |
| Benton, G. L. | 342,564 | May 25, 1886 | B |
| Benton, G. L. | 342,565 | May 25, 1886 | B |
| Berend, Ludwig. | 1,167,373 | Jan. 11, 1916 | D 1 |
| Blacher, L. & Sztencel, S. | 856,276 | Apr. 26, 1910 | I |
| Black, J. C. | 968,640 | Aug. 30, 1910 | D 1 |
| Black, J. C. | 1,152,478 | Sept. 7, 1915 | F 3 |
| Black, J. C. | 1,164,162 | Dec. 14, 1915 | D 2, F 3 |
| Blowski, Jno. & Blowski, A. | 1,186,373 | June 6, 1916 | I |
| Born, Sidney. | 1,234,124 | July 24, 1917 | F 1, II, S |
| Borrman, C. H. | 1,220,067 | Mar. 20, 1917 | F 2, II |
| Bowman, F. | 12,852 | May 15, 1855 | F 1, 1 |
| Brace, H. B. & Swart, Wm. T. | 54,495 | May 8, 1866 | M, G |
| Brackebusch, Hans. | 275,565 | Apr. 10, 1883 | D 1 |
| Bradford, Geo. | 806,116 | Nov. 21, 1905 | F 1, 5 |
| Bragg, John. | 604,515 | May 24, 1898 | V, D 1 |
| Braggins, Edw. | 46,633 | Mar. 7, 1865 | F 5 |
| Braun, Otto. | 243,496 | June 28, 1881 | U |
| Breinig, Revere | 306,897 | Oct. 21, 1884 | I |
| Brooks, Essex & Smith | 1,191,916 | July 18, 1916 | L |
| Brooks and Smith | 1,231,123 | June 26, 1917 | L |
| Brickman, Saml. | 1,279,506 | Sept. 24, 1918 | F |
| Brown, Arthur L. | 1,234,862 | July 31, 1917 | D 2 |
| Brown, Ernest. | 1,225,569 | May 8, 1917 | D 2 |
| Brown, D. P. & Neeley, J. W. | 361,671 | Apr. 26, 1887 | F 1, 2 |
| Brown, E. G. Cammann, O. N. & Willcox, O. | 510,672 | Dec. 12, 1893 | F 1, 2, 4 |
| Brown, L. W. | 994,100 | May 30, 1911 | A |
| Brown, W. A. | 1,309,794 | July 15, 1919 | A |
| Brown, Wm. | 10,055 | Sept. 27, 1853 | C, W |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Brownlee, R. H. & Uhlinger | 1,265,043 | May 7, 1918 | K 3, B |
| Brownlee, R. H. | 1,308,161 | July 1, 1919 | F |
| Brucke, Otto. | 963,510 | July 5, 1910 | A |
| Brundred, Wm. J. | 148,806 | Mar. 24, 1974 | F 2 |
| Bullard, John. | 34,195 | Jan. 21, 1862 | G |
| Burcey, Chas. J. T. | 122,810 | Jan. 16, 1872 | F |
| Burch, Eli F. | 1,238,101 | Aug. 28, 1917 | O, T |
| Burdon, J., W. M. & M. M. | 1,112,051 | Sept. 29, 1914 | K 1 |
| Burghardt, C. A. | 309,027 | Dec. 9, 1884 | U |
| Burk, H. R. | 284,811 | Sept. 11, 1883 | G |
| Burke, A. M. & Wright, S. | 65,999 | June 25, 1867 | D 1 |
| Burket, D. M. & Gray, J. C. | 57,285 | Aug. 21, 1866 | O |
| Burrows, H. G. | 998,937 | July 25, 1911 | F 2, H |
| Burton, W. M. | 1,055,707 | Mar. 11, 1913 | B, E 2 |
| Burton, W. M. | 1,049,667 | Jan. 7, 1913 | B, J |
| Burton, W. M. | 1,105,961 | Aug. 4, 1914 | J, B |
| Burton, W. M. | 1,112,113 | Sept. 29, 1914 | C, B |
| Burton, W. M. | 1,167,884 | Jan. 11, 1916 | B |
| Burwell, A. W. & Sherman, L. O. | 738,656 | Sept. 8, 1903 | V, D 1 |
| Bush, Asa A. | 269,382 | Dec. 19, 1882 | F 1 |
| Busse, Heinrich. | 376,289 | Jan. 10, 1888 | T |
| Byerley, Francis X. | 347,288 | Aug. 10, 1886 | C, F |
| Byerley, F. X. | 524,120 | Aug. 7, 194 | E 2, 3, F |
| Byerley, F. X. | 547,329 | Oct. 1, 1895 | F 4, 2 |
| Byerley, F. X. | 244,431 | July 19, 1881 | C |
| Byerley, F. X. | 132,353 | Oct. 22, 1872 | C |
| Byerley, F. X. | 164,672 | June 22, 1875 | C |
| Biggins, James E. | 1,274,976 | Aug. 6, 1918 | B |
| Black, John C. | 1,275,648 | Aug. 13, 1918 | J |
| Boyle, Alex. M. | 1,276,866 | Aug. 27, 1918 | W |
| Buerger, C. B. | 1,302,761 | May 6, 1919 | S |
| Calkins, A. C. | 779,398 | Jan. 3, 1905 | B |
| Calkins, A. C. | 769,681 | Sept. 6, 1904 | D 1 |
| Campbell, Andrew. | 999,628 | Aug. 1, 1911 | C |
| Cantour, David. | 552,206 | Jan. 14, 1896 | F |
| Carman, F. J. | 501,988 | July 25, 1893 | V |
| Carpenter, Calvin, Jr. | 82,083 | Sept. 15, 1868 | O |
| Carter, G. F. | 680,639 | Aug. 13, 1901 | S |
| Catlin, Robert M. | 1,272,377 | July 16, 1918 | W |
| Cazin, Francis F. M. | 400,634 | Apr. 2, 1889 | F |
| Cazin, F. M. F. | 400,633 | Apr. 2, 1889 | V, G |
| Chamberlain, H. P. | 1,221,790 | Apr. 3, 1917 | B |
| Chemin, Jean C. O. | 297,766 | Apr. 29, 1884 | F, D |
| Cheney, Samuel. | 230,239 | July 20, 1880 | F 2 |
| Cherry, Cummings. | 15,642 | Sept. 2, 1856 | A |
| Cherry, C. | 15,643 | Sept. 2, 1856 | W |
| Cherry, L. B. | 1,229,886 | June 12, 1917 | B, P |
| Chesebrough, Robt. A. | 127,568 | June 4, 1872 | M |
| Chesebrough, Robt. A. | 237,484 | Feb. 8, 1881 | M |
| Chesebrough, R. A. | 49,502 | Aug. 22, 1865 | G, S |
| Chesebrough, R. A. | 48,367 | June 27, 1865 | S |
| Chesebrough, R. A. | 51,557 | Dec. 19, 1865 | S |
| Chesebrough, R. A. | 51,558 | Dec. 19, 1865 | S |
| Chesebrough, R. A. | 542,704 | Aug. 21, 1894 | F 2, H |
| Chevrier, Gervais. | 106,915 | Aug. 30, 1870 | I |
| Childs, Samuel. | 11,059 | June 13, 1854 | F 1, 2, I |
| Clarke, Edward. | 232,685 | Sept. 28, 1880 | I |
| Clark, Edward M. | 1,119,496 | Dec. 1, 1914 | B |
| Clark, E. M. | 1,129,034 | Feb. 16, 1915 | B |
| Clark, E. M. | 1,132,163 | Mar. 16, 1915 | B |
| Clark, C. E. | 1,147,608 | July 20, 1915 | K 1 |
| Clark, Frank W. | 547,332 | Oct. 1, 1895 | F 3, 4 |
| Clark, R. C. & Beecher, W. F. | 275,589 | Apr. 10, 1883 | F 1, 4 |
| Clark, R. C. & Warren, M. H. | 298,825 | May 20, 1884 | F |
| Clark, R. C. & Warren, M. H. | 318,698 | May 26, 1885 | F |
| Clark, S. G. | 34,816 | Apr. 1, 1862 | G, F 2, H |
| Clifford, Victor | 1,266,407 | May 14, 1918 | H |
| Coast, John W., Jr. | 1,250,798 | Dec. 18, 1917 | B |
| Coast, J. W., Jr. | 1,250,800 | Dec. 18, 1917 | B |
| Coast, J. W., Jr. | 1,250,801 | Dec. 18, 1917 | B |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Coast, J. W., Jr. | 1,252,401 | Jan. 8, 1918 | B |
| Coast, J. W., Jr. | 1,253,000 | Jan. 8, 1918 | B |
| Coast, J. W., Jr. | 1,258,190 | Mar. 5, 1918 | B |
| Coast, J. W., Jr. | 1,252,999 | Jan. 8, 1918 | B |
| Coast, J. W., Jr. | 1,291,414 | Jan. 14, 1919 | B |
| Coast, J. W., Jr. | 1,307,724 | June 24, 1919 | S |
| Coast, John W., Jr. | 1,250,799 | Dec. 18, 1917 | B |
| Coast, John W., Jr. | 1,258,191 | Mar. 5, 1918 | B |
| Cobb, J. O. | 1,201,558 | Oct. 17, 1916 | A |
| Cobb, E. B. | 1,300,816 | Apr. 15, 1919 | D |
| Cochran, A. | 1,296,367 | Mar. 4, 1919 | B |
| Cole, Jas., Jr. | 128,169 | Sept. 12, 1876 | F 2, 4, II |
| Coleman, John T. | 19,406 | May 29, 1877 | F |
| Colin, Theodore F. | 607,017 | July 12, 1898 | V, D 1 |
| Colin, T. F. | 723,368 | Mar. 24, 1903 | V, D |
| Colin, T. F. | 744,720 | Nov. 24, 1903 | V, D |
| Colin, T. F. | 685,907 | Nov. 5, 1901 | V, D |
| Collins, Jacob | 1,029,439 | June 4, 1912 | A |
| Collins, John F. | 59,334 | Oct. 30, 1866 | F 4, I |
| Collins, Jos. G. | 32,557 | June 18, 1861 | S |
| Connelly, Martin | 240,093 | Apr. 12, 1881 | D 1, V |
| Connelly, Martin | 240,094 | Apr. 12, 1881 | D 1, V |
| Cook & Price | 1,190,633 | July 11, 1916 | E 3 |
| Cooper, A. S. | 67,226 | Jan. 3, 1899 | E 2, 3 |
| Corfield, Wm. | 54,061 | Apr. 17, 1866 | M |
| Corfield, Wm. | 54,060 | Apr. 17, 1866 | M |
| Cornell, Sidney | 1,202,969 | Oct. 31, 1916 | F 2 |
| Cosden, J. S. | 981,176 | Jan. 19, 1911 | F 2, II |
| Cosden, J. S. & Coast, J. W., Jr. | 258,196 | Mar. 5, 1918 | B |
| Cosden & Coast | 1,261,215 | Apr. 2, 1918 | B |
| Cottrell & Wright | 987,117 | Mar. 21, 1911 | P |
| Cottrell & Speed | 987,115 | Mar. 21, 1911 | P, A |
| Cottrell & Speed | 987,116 | Mar. 21, 1911 | P |
| Cottrell, F. G. | 987,114 | Mar. 21, 1911 | P |
| Courtois, F. A. | 788,250 | Apr. 25, 1905 | N |
| Cowan, Wm. P. | 558,358 | Apr. 14, 1896 | C |
| Crane, Frederick D. | 1,223,153 | Apr. 17, 1917 | M, D |
| Crane, Gerard | 231,280 | Aug. 17, 1880 | E 1 |
| Crane, Adolphus G. | 1,276,879 | Aug. 27, 1918 | E 1 |
| Crawford, Benjamin | 113,023 | Mar. 28, 1871 | B |
| Crocker, Saml. H. | 120,463 | July 16, 1872 | B |
| Cronemeyer, A. H. | 718,318 | Jan. 13, 1903 | V |
| Cronenberger, W. M. | 1,152,399 | Sept. 7, 1915 | W |
| Cronin, C. J. | 150,465 | May 5, 1874 | F |
| Cross, James P. | 57,095 | Aug. 14, 1866 | M |
| Cross, Roy | 1,255,138 | Feb. 5, 1918 | F 1, 2 |
| Cross, Walter M. | 1,203,312 | Oct. 3, 1916 | F |
| Culmer, Geo. & Geo. C. K. | 635,429 | Oct. 24, 1899 | F |
| Culmer, Geo. & Geo. C. K. | 635,430 | Oct. 24, 1899 | W |
| Culmer, J. W. | 217,995 | July 29, 1879 | G |
| Cunningham, Christopher | 158,042 | Dec. 22, 1874 | C |
| Danckwardt, P. | 1,141,529 | June 1, 1915 | J, F 1, II |
| Daul, John | 213,395 | Mar. 18, 1879 | F 2 |
| Daul, Louis | 258,284 | May 23, 1882 | F 2 |
| Davidson, J. G. & Ford, R. W. | 1,228,042 | June 5, 1917 | P |
| Davidson, Samuel | 1,238,644 | Aug. 28, 1917 | J, K 2 |
| Davis, John T. | 671,078 | Apr. 2, 1901 | F 1, II |
| Davis, John T. | 1,159,186 | Nov. 2, 1915 | F 2, II |
| Davis, Samuel | 65,884 | June 18, 1867 | S |
| Day, David T. | 826,089 | July 17, 1906 | A, V |
| Day, D. T. | 1,004,632 | Oct. 3, 1911 | B |
| Day, D. T. | 1,221,698 | Apr. 3, 1917 | B, D |
| Day, D. T. | 826,089 | July 17, 1906 | V, D |
| Day, D. T. | 1,280,178 | Oct. 1, 1918 | W |
| Day, Roland B. | 1,280,179 | Oct. 1, 1918 | B |
| Dayton, W. C. | 1,174,971 | Mar. 14, 1916 | K 1 |
| Dayton, W. C. | 1,174,970 | Mar. 14, 1916 | K 1 |
| Dean, Richard | 290,866 | Dec. 25, 1883 | F 2, II |
| Dean, Richard | 305,056 | Sept. 16, 1884 | F 1, 2, II |
| Dean, Richard | 310,497 | Jan. 6, 1885 | F |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Dean, R. | 314,368 | Mar. 24, 1885 | F 1, 2, 3, II |
| Dean, R. | 342,500 | May 25, 1886 | F 2, II |
| Dehnst, Julius | 1,112,602 | Oct. 6, 1914 | V, D |
| De Smedt, Edw. J. | 236,995 | Jan. 25, 1881 | E 1, 2 |
| De Smedt, E. J. | 237,662 | Feb. 8, 1881 | E 1, 2 |
| Devericks, F. C. | 1,260,970 | Mar. 26, 1918 | J, K 2 |
| Dewar, J. & Redwood, B. | 419,931 | Jan. 21, 1890 | B |
| Dewar & Redwood | 426,173 | Apr. 22, 1890 | B |
| Dewitt, Henry C. | 63,299 | Mar. 26, 1867 | M |
| Ditmar, Peter | 246,096 | Aug. 23, 1881 | M |
| Devine, S. R. & Seely, C. A. | 55,071 | May 29, 1866 | F 2 |
| Dickey, Julius C. | 166,349 | Aug. 3, 1875 | F 1 |
| Diehl, H. A. | 469,777 | Mar. 1, 1892 | E 2, 3 |
| Deiterichs, E. F. | 253,990 | Feb. 21, 1882 | F 1, 2 |
| Divine, R. E. | 1,303,779 | May 13, 1919 | I |
| Divine, R. E. | 1,303,662 | Apr. 22, 1919 | I |
| Divine, R. E. | 1,303,663 | Apr. 22, 1919 | I |
| Doe, Wm. | 174,789 | Mar. 14, 1876 | S |
| Dow, Allan W. | 688,073 | Dec. 3, 1901 | E 1, 2, B |
| Downard, J. S. & Roloson, B. A. | 722,500 | Mar. 10, 1903 | E 2 |
| Downer, Wm. P. | 44,519 | Oct. 4, 1864 | D 1 |
| Drake, Thos. | 471,863 | Mar. 29, 1892 | L |
| Draper, Henry V. P. | 238,867 | Mar. 15, 1881 | G, D |
| Drayton, Thos. | 11,239 | July 4, 1854 | D |
| Dubbs, Henry | 161,672 | Apr. 6, 1875 | D, S |
| Dubbs, Jesse A. | 470,911 | Mar. 15, 1892 | V |
| Dubbs, J. A. | 646,639 | Apr. 3, 1900 | F 2, 4 |
| Dubbs, J. A. | 1,002,570 | Sept. 5, 1911 | A, F |
| Dubbs, J. A. | 1,100,717 | June 23, 1914 | B |
| Dubbs, J. A. | 1,057,227 | Mar. 25, 1913 | E 2 |
| Dubbs, J. A. | 694,621 | Mar. 4, 1902 | F 4, II |
| Dubbs, J. A. | 694,622 | Mar. 4, 1902 | F 4 |
| Dubbs, J. A. | 407,182 | July 16, 1889 | V, D |
| Dubbs, J. A. | 1,123,502 | Jan. 5, 1915 | A |
| Dubbs, J. A. | 1,135,506 | Apr. 13, 1915 | E 2, B |
| Dubbs, C. P. | 1,231,509 | June 26, 1917 | B |
| Dubbs, C. P. | 1,231,509 | June 26, 1917 | B |
| Dubler, John B. | 251,770 | Jan. 3, 1882 | F |
| Dubler, J. B. | 283,471 | Aug. 21, 1883 | F 1, II |
| Dubreuil, A. | 48,265 | June 20, 1865 | F 2 |
| Duffus, G. H. S. | 46,088 | Jan. 31, 1865 | F, S |
| Duffus, G. H. S. | 46,089 | Jan. 31, 1865 | F, S |
| Duffus, G. H. S. | 46,090 | Jan. 31, 1865 | F, S |
| Dundas, R. C. | 1,056,980 | Mar. 25, 1913 | E 2, B |
| Dundas, R. C. | 1,120,039 | Dec. 8, 1914 | F 1, II |
| Dundas, R. C. | 1,257,199 | Feb. 19, 1918 | B |
| Dunham, F. H. | 1,003,040 | Sept. 12, 1911 | E |
| Dunham, F. H. | 1,013,283 | Jan. 2, 1912 | E 2 |
| Dunkle, Allen H. | 530,300 | Dec. 4, 1894 | U |
| Dunscomb, Edward | 62,739 | Mar. 12, 1867 | S |
| Dupias, A. C. G. & Fell, W. S. | 749,368 | Jan. 12, 1904 | F, S |
| Durant, C. W. & Griffith, J. | 132,263 | Oct. 15, 1872 | U |
| Dvorkovitz, Paul | 546,697 | Sept. 24, 1895 | F 2 |
| Dyar, N. A. & Augustus, J. F. | 25,362 | Sept. 6, 1859 | M |
| Dyer, E. I. | 1,207,381 | Dec. 5, 1916 | A |
| Dyer, E. I. | 1,220,504 | Mar. 27, 1917 | A |
| Dyer, E. I. & Heise, A. R. | 1,242,784 | Oct. 9, 1917 | A |
| Dyer, Frank L. | 579,360 | Mar. 23, 1897 | F 2, 5 |
| Dyer, Walter | 1,256,535 | Feb. 19, 1918 | D |
| Dyer, Walter & W. E. | 1,256,536 | Feb. 19, 1918 | D |
| Earle, G. W. | 1,221,038 | Apr. 3, 1917 | H |
| Eaton, Richard | 110,638 | Jan. 3, 1871 | O |
| Edeleanu, Lazar | 911,553 | Feb. 2, 1909 | D |
| Edgerton, Henry H. | 159,655 | Feb. 9, 1875 | K 1 |
| Edwards, E. A. | 439,745 | Nov. 4, 1890 | F 2, 4, II |
| Edwards, Jos. B. | 100,874 | Mar. 15, 1870 | F 2 |
| Edwards, Jos. B. | 1,277,884 | Sept. 3, 1918 | B |
| Eggleston, J. E. | 1,018,040 | Feb. 20, 1912 | F, V |
| Eldred, B. E. & Mersereau, G. | 1,234,886 | July 31, 1917 | B |

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| Name | Number | Date | Class |
|---|---|---|---|
| Elliott, W. S. | 1,242,667 | Oct. 9, 1917 | A, D |
| Ellis, Carleton | 1,089,359 | Mar. 3, 1914 | O |
| Ellis, Carleton | 1,191,880 | July 18, 1916 | D, L |
| Ellis, C. | 1,216,971 | Feb. 20, 1917 | B |
| Ellis, C. | 1,249,278 | Dec. 4, 1917 | J, B |
| Ellis, C. | 1,295,825 | Feb. 25, 1919 | B |
| Ellis, Jno. & Kattell, E. C. | 63,789 | Apr. 16, 1867 | F 2, II |
| Ellis & Kattell | 68,860 | Sept. 17, 1867 | F 2, II |
| Ellithorp, S. B. | 52,277 | Jan. 30, 1866 | U |
| Emory, F. F. | 1,148,834 | Aug. 3, 1915 | S |
| Engle, Jacob P. | 481,391 | Aug. 23, 1892 | A |
| Engle, J. P. | 481,392 | Aug. 23, 1892 | A |
| Erickson, Emil T. | 1,281,320 | Oct. 15, 1918 | W |
| Erwin, J. B. & O. R. | 1,085,805 | Feb. 3, 1914 | H |
| Eva, Gray & Christy | 1,100,126 | June 16, 1914 | O |
| Evans, Edward | 1,257,829 | Feb. 26, 1918 | V |
| Everest, H. B. | 212,914 | Mar. 4, 1879 | F |
| Everest, H. B. | 68,426 | Sept. 3, 1867 | F 2, 5, II |
| Ewing, Chas. R. | 1,083,998 | Jan. 13, 1914 | S |
| Ewing, M. P. | 56,852 | July 31, 1866 | F 2, 5, II |
| Ewing, M. P. & Everest, H. B. | 58,021 | Sept. 11, 1866 | F 2, 5, II |
| Fagan, John G. | 1,148,763 | Aug. 3, 1915 | H |
| Fairchild, J. H. | 53,528 | Mar. 27, 1866 | U |
| Fales, Levi S. | 49,740 | Sept. 5, 1865 | S |
| Fales, L. S. | 52,151 | Jan. 23, 1866 | F, U |
| Fales, L. S. | 49,739 | Sept. 5, 1865 | F 4, I |
| Fales, L. S. | 97,182 | Nov. 23, 1869 | I |
| Farrar, Alonzo | 96,097 | Oct. 26, 1869 | D |
| Farrar, A. | 100,876 | Mar. 15, 1870 | I |
| Faucett, H. W. & McGowan, T. | 133,426 | Nov. 26, 1872 | S, F |
| Faucett & McGowan | 133,425 | Nov. 26, 1872 | S, D |
| Faucett & McGowan | 117,873 | Aug. 8, 1871 | U |
| Fazi, Romolo de | 1,108,351 | Aug. 25, 1914 | M |
| Felizat, Louis | 1,070,435 | Aug. 19, 1913 | D |
| Felton, D. F. | 1,179,296 | Apr. 11, 1916 | K 1 |
| Farrar, F. F. & Gill, F. P. | 206,309 | July 23, 1878 | I |
| Fichet, L. V. | 53,964 | Apr. 17, 1866 | F 2, II |
| Field, John K. | 408,472 | Aug. 6, 1889 | D 1 |
| Fleming, J. C. | 956,065 | Apr. 26, 1910 | S, A |
| Fleury, Huot | 50,571 | Oct. 24, 1865 | F 5, D |
| Flowers, Geo. W., Happersett, J. C. & Happersett, D. W. | 74,756 | Feb. 25, 1868 | M |
| Fordied, John | 54,267 | Apr. 24, 1866 | W, D 1 |
| Forrest, Chas. N. | 1,163,593 | Dec. 7, 1915 | E 1, 3 |
| Forward, C. B. | 1,189,083 | June 27, 1916 | B, J |
| Forward, C. B. | 11,181,301 | May 2, 1916 | F 2, II |
| Forward, C. B. | 1,202,823 | Oct. 31, 1916 | B |
| Forward, C. B. | 998,569 | July 18, 1911 | E 2, B |
| Forward, C. B. | 1,100,966 | June 23, 1914 | B |
| Forward, C. B. | 1,088,693 | Mar. 3, 1914 | B |
| Forward, C. B. | 1,088,692 | Mar. 3, 1914 | E 2, B |
| Forward, C. B. | 1,247,808 | Nov. 27, 1917 | U |
| Forward, C. B. | 1,255,149 | Feb. 5, 1918 | B |
| Forward, C. B. | 1,274,405 | Aug. 6, 1918 | B |
| Forward, C. B. | 1,299,449 | Apr. 8, 1919 | F |
| Forward, C. B. & Davidson, J. M. | 611,620 | Oct. 4, 1898 | E 2, 3, D 1 |
| Foubert, Andre | 71,156 | Nov. 19, 1867 | F 2 |
| Foubert, Andre | 118,602 | Aug. 29, 1871 | F |
| Foubert, Andre | 60,166 | Dec. 4, 1866 | F 1 |
| Fowler, David W. | 75,147 | Mar. 3, 1868 | M |
| Franke, A. H. | 1,142,512 | June 8, 1915 | A |
| Frasch, Hans A. | 488,628 | Dec. 27, 1892 | I |
| Frasch, Hans A. | 640,292 | Jan. 2, 1900 | F 2, II |
| Frasch, Hans A. | 525,811 | Sept. 11, 1894 | D 1 |
| Frasch, Hans A. | 581,546 | Apr. 27, 1897 | E 2, 3 |
| Frasch, Hans A. | 1,212,620 | Jan. 16, 1917 | B |
| Frasch, Herman | 845,735 | Feb. 26, 1907 | F 2, II |
| Frasch, Herman | 968,760 | Aug. 30, 1910 | F 1 |
| Frasch, Herman | 487,216 | Nov. 29, 1892 | V |

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| Name | Number | Date | Class |
|---|---|---|---|
| Frasch, Herman | 564,920 | July 28, 1896 | V |
| Frasch, Herman | 490,144 | Jan. 17, 1893 | V |
| Frasch, Herman | 553,191 | Jan. 14, 1896 | S |
| Frasch, Herman | 561,216 | June 2, 1896 | D 1 |
| Frasch, Herman | 564,921 | July 28, 1896 | V |
| Frasch, Herman | 448,480 | Mar. 17, 1891 | V |
| Frasch, Herman | 378,246 | Feb. 21, 1888 | V, D |
| Frasch, Herman | 951,729 | Mar. 8, 1910 | G, D |
| Frasch, Herman | 951,272 | Mar. 8, 1910 | G, D |
| Frasch, Herman | 622,799 | Apr. 11, 1899 | V |
| Frasch, Herman | 190,483 | May 8, 1877 | F 2, 4 |
| Frasch, Herman | 630,496 | Aug. 8, 1899 | V |
| Frasch, Herman | 500,252 | June 27, 1893 | V |
| Frasch, Herman | 572,676 | Dec. 8, 1896 | V, D |
| Frasch, Herman | 321,420 | Aug. 24, 1880 | U |
| Frasch, Herman | 205,792 | Aug. 3, 1878 | F |
| Frasch, Herman | 649,047 | May 8, 1900 | O, V |
| Frasch, Herman | 340,499 | Apr. 20, 1886 | F |
| Frasch, Herman | 487,119 | Nov. 29, 1892 | V |
| Frasch, Herman | 281,045 | July 10, 1883 | F 2, 3 |
| Frasch, Herman | 564,922 | July 28, 1896 | V |
| Frasch, Herman | 564,923 | July 28, 1896 | V |
| Frasch, Herman | 564,924 | July 28, 1896 | V, F |
| Frasch, Herman | 649,048 | May 8, 1900 | V, D |
| Frasch, Herman | 542,849 | July 16, 1895 | V, D 1 |
| Frasch, Herman | 543,619 | July 30, 1895 | V |
| Fraser, William M. | 1,259,223 | Mar. 12, 1918 | E 1, 2 |
| Fraser, Wm. M. | 1,258,103 | Mar. 5, 1918 | E 1, 2 |
| Frederici, C. F. | 48,672 | July 11, 1865 | F |
| Freel, John | 504,917 | Sept. 12, 1893 | S, F |
| Gaggin, Richard | 118,359 | Aug. 22, 1871 | D 2, V |
| Gallsworthy, Benjamin | 1,234,327 | July 24, 1917 | F 2, II |
| Galloupe, J. H. | 1,283,723 | Nov. 5, 1918 | W |
| Gardner, J. & Harris, J. F. | 442,802 | Dec. 15, 1890 | V, F |
| Garner, J. B. & Clayton, H. D. | 1,262,769 | Apr. 16, 1918 | L |
| Garner, J. B. | 1,299,455 | Apr. 8, 1919 | J, K |
| Garrity, W. F. & Jarvis, A. | 1,190,538 | July 11, 1916 | O, A |
| Gravey, Benjamin | 29,218 | July 17, 1860 | G |
| Gathmann, Louis | 768,796 | Aug. 30, 1904 | F 1, 5 |
| Gathmann, Louis | 755,760 | Mar. 29, 1904 | F |
| Gay, Cassius M. | 1,179,001 | Apr. 11, 1916 | J |
| Gearing, C. M. | 212,084 | Feb. 4, 1879 | F 1, II |
| Gellen, A. | 1,063,025 | May 27, 1813 | I |
| Gengembre, H. P. | 52,283 | Jan. 30, 1866 | A |
| Gengembre, H. P. | 52,284 | Jan. 30, 1866 | A |
| Gengembre, H. P. | 24,454 | June 21, 1859 | G |
| Gengembre, H. P. | 25,109 | Aug. 16, 1859 | G, B |
| Gengembre, H. P. | 27,542 | Mar. 20, 1860 | G, W |
| Gengembre, H. P. | 33,699 | Nov. 12, 1861 | G |
| Gerbeth, F. L. de | 81,071 | Aug. 18, 1867 | L, P |
| Gesner, Abraham | 11,205 | June 27, 1854 | G |
| Gesner, A. | 11,203 | June 27, 1854 | G |
| Gesner, A. | 11,204 | June 27, 1854 | G |
| Gibbons, Samuel | 87,485 | Mar. 2, 1869 | O |
| Gibbons, S. | 87,658 | Mar. 9, 1869 | F |
| Gibbons, S. | 85,810 | Jan. 12, 1869 | F 2, II |
| Gibbons, S. | 68,974 | Sept. 17, 1867 | F 1, 2, II |
| Gillespie, Jas. | 23,362 | Mar. 29, 1859 | G, F |
| Gillons, G. H. | 1,084,080 | Jan. 13, 1914 | F 1, II |
| Goldwater, Henry | 366,720 | July 19, 1887 | F 1, 2, II |
| Goldwater, Henry | 432,525 | July 22, 1890 | S |
| Goodaire, Wm. & Stead, Geo. | 101,003 | Mar. 22, 1870 | I |
| Gordon, Thos. | 451,724 | May 5, 1891 | D |
| Govers, F. X. | 1,297,833 | Mar. 18, 1919 | W |
| Gracie, John | 114,802 | May 16, 1871 | F 4 |
| Gracie, John | 114,803 | May 16, 1871 | F |
| Gracie, John | 117,405 | July 25, 1871 | F |
| Gracie, John | 117,406 | July 25, 1871 | F 1, I |
| Gracie, John | 99,081 | Jan. 25, 1870 | F 1, II |
| Grady, Chas. F. | 556,412 | Mar. 17, 1896 | F 2, II |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Graham, C. B. | 732,937 | July 7, 1903 | D 1 |
| Grannis, C. W. | 36,403 | Sept. 9, 1862 | U, G |
| Grant, Jas. B. | 57,311 | Aug. 21, 1866 | F |
| Grant, J. B. & Mason, A. | 339,545 | Apr. 6, 1886 | F 1, 2, 5, II |
| Grant & Mason | 339,546 | Apr. 6, 1886 | F 2, 5, II |
| Gray, A. McD. | 653,235 | July 10, 1900 | C |
| Gray, Daniel T. | 250,524 | Dec. 6, 1881 | C |
| Gray, D. T. | 248,735 | Oct. 25, 1881 | C |
| Gray, D. T. | 281,491 | July 17, 1883 | C, S |
| Gray, E. B. | 1,005,425 | Oct. 10, 1911 | I |
| Gray, G. W. | 1,193,540 | Aug. 8, 191[illegible] | B, J |
| Grant & Mason | 339,545 | Apr. 6, 1886 | A |
| Grant, H. F. | 1,303,292 | May 13, 1919 | O |
| Gray, G. W. | 1,193,541 | Aug. 8, 1916 | B |
| Gray, J. L. | 923,429 | June 1, 1909 | I |
| Gray, J. L. | 923,428 | June 1, 1909 | I |
| Gray, J. L. | 1,192,889 | Aug. 1, 1916 | F |
| Gray, J. L. | 923,427 | June 1, 1909 | I |
| Gray T. T. | 1,158,205 | Oct. 26, 1915 | P |
| Gregory, Ralph | 1,271,511 | July 2, 1918 | S |
| Greene, H. J. | 1,252,000 | Jan. 1, 1918 | K 1 |
| Green, Joel | 46,794 | Mar. 14, 1865 | K 2 |
| Greenstreet, Chas. J. | 1,110,924 | Oct. 26, 1915 | B |
| Greenstreet, Chas. J. | 1,110,923 | Sept. 15, 1914 | B |
| Greenstreet, C. J. | 1,110,925 | Sept. 15, 1914 | B |
| Greenstreet, C. J. | 1,166,982 | Sept. 15, 1914 | B |
| Greenstreet, C. J. | 1,299,172 | Apr. 1, 1919 | B |
| Grieg, A. & Smith, Jas. | 42,121 | Mar. 29, 1864 | K 1 |
| Griffin, Jonathan | 23,167 | Mar. 8, 1869 | M |
| Groble, J. C. | 1,283,502 | Nov. 5, 1918 | K |
| Grogan, Henry | 94,409 | Aug. 31, 1869 | F 2 |
| Grogan, H. & Lape, G. T. | 89,988 | May 11, 1869 | F 2, 5, II |
| Grousilliers, Hector de | 378,774 | Feb. 28, 1888 | I |
| Guillaume, Emile. | 996,081 | June 27, 1911 | B |
| Gulick, W. R. | 1,187,061 | June 13, 1916 | M |
| Gumpoldt, Emil. | 616,838 | Dec. 27, 1898 | M |
| Gesner, Abraham | 12,612 | Mar. 27, 1855 | G |
| Hadley, B. E. | 1,300,230 | Apr. 8, 1919 | S |
| Hague, S. L. | 775,448 | Nov. 22, 1904 | W, S |
| Hague, S. L. | 759,988 | May 17, 1904 | W, S |
| Hall, C. H. | 86,535 | Feb. 2, 1869 | F 2 |
| Hall, C. H. | 55,855 | June 26, 1866 | F 1, 2, II |
| Hall, C. H. & Ellis, John | 58,813 | Oct. 16, 1866 | F 1, II |
| Hall, T. G. | 372,672 | Nov. 8, 1887 | V |
| Hall, Wm. A. | 1,175,909 | Mar. 14, 1916 | B |
| Hall, Wm. A. | 1,105,772 | Aug. 4, 1914 | B, K 1 |
| Hall, Wm. A. | 1,194,289 | Aug. 8, 1916 | B |
| Hall, Wm. A. | 1,239,099 | Sept. 4, 1917 | B |
| Hall, Wm. A. | 1,175,910 | Mar. 14, 1916 | B, K 1 |
| Hall, Wm. A. | 1,247,671 | Nov. 27, 1917 | B |
| Hall, Wm. A. | 1,242,795 | Oct. 9, 1917 | B |
| Hall, Wm. A. | 1,242,796 | Oct. 9, 1917 | B |
| Hall, Wm. A. | 1,239,100 | Sept. 14, 1917 | B |
| Hall, Wm. A. | 1,261,930 | Apr. 9, 1918 | B |
| Hall, Wm. A. | 1,242,746 | Oct. 9, 1917 | B |
| Hall, Wm. A. | 1,242,795 | Oct. 9, 1917 | B |
| Hall, Wm. A. | 1,285,136 | Nov. 19, 1918 | B |
| Hall, Wm. C. | 266,990 | Nov. 7, 1882 | F 2 |
| Hamilton, T. S. | 1,018,871 | Feb. 27, 1912 | A |
| Halvorson, Halvor | 305,182 | Sept. 16, 1884 | S |
| Halvorson, H. | 305,180 | Sept. 16, 1884 | F |
| Hand, Harry W. | 596,874 | Jan. 4, 1898 | U, S |
| Handy, Jas. O. | 1,281,354 | Oct. 15, 1918 | O |
| Handy, Jas. O. | 1,084,738 | Oct. 15, 1918 | O |
| Hansen, Julius. | 1,281,355 | Jan. 20, 1914 | C |
| Hardy, C. A. | 51,042 | Nov. 21, 1865 | F |
| Hardy, C. A. | 40,168 | Oct. 6, 1863 | F 2, 4 |
| Hardy, C. A. | 46,899 | Mar. 21, 1865 | F |
| Harris, Ford W. | 1,281,952 | Oct. 15, 1918 | A, P |

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| Name | Number | Date | Class |
|---|---|---|---|
| Harris, John | 1,283,508 | Nov. 5, 1918 | K 2 |
| Harris, Milo | 170,730 | Dec. 7, 1875 | U |
| Hart, Thos. M. | 1,252,433 | Jan. 8, 1918 | A, E 2, 3 |
| Hartshorn, H. M. | 91,843 | June 29, 1869 | N |
| Hastings, D. & Brink, A. W. | 867,505 | Oct. 1, 1907 | K 2, J |
| Hatch, N. B. | 22,798 | Feb. 1, 1859 | G |
| Hawes, Benj. N. | 444,833 | Jan. 20, 1891 | V |
| Hazlett, R. W. & Hobbs, J. H. | 24,211 | May 31, 1859 | G, S |
| Hebard, Benj. F. | 31,457 | Feb. 19, 1861 | M |
| Heckenbleikner & Gilchrist | 1,310,078 | July 15, 1919 | I |
| Helbing, H. & Passmire, F. W. | 666,010 | Jan. 15, 1901 | D 1 |
| Hempel, H. | 621,338 | Mar. 21, 1899 | M |
| Hempel, H. | 621,411 | Mar. 21, 1899 | M |
| Henderson, Geo. A. | 1,266,261 | May 14, 1918 | E 1 |
| Henderson, N. M. | 490,199 | Jan. 17, 1893 | C |
| Henderson, N. M. | 340,878 | Apr. 27, 1886 | F |
| Hennebutte, H. | 1,165,878 | Dec. 28, 1915 | F |
| Hennebutte, H. | 1,165,877 | Dec. 28, 1915 | F 4, I |
| Hense, Rudolf | 1,073,233 | Sept. 16, 1913 | M |
| Herber, Samuel M. | 1,111,580 | Sept. 22, 1914 | F, D 1 |
| Herber, S. M. | 1,183,457 | May 16, 1916 | F 2, 3, D |
| Hibbert, Harold | 1,270,759 | June 25, 1918 | B, K 2 |
| Higbie, M. S. & Dougherty, A. | 387,358 | Aug. 7, 1888 | C, E, 1 |
| Higbie, M. S. & Dougherty, A. | 387,357 | Aug. 7, 1888 | C, E, 1, 3 |
| Higgins, Chas. S. | 309,718 | Dec. 23, 1884 | N |
| Higham, A. D. | 54,157 | Apr. 24, 1866 | F |
| Hill, R. L. | 1,269,439 | June 11, 1918 | B |
| Hill, S. & Thumm, C. F. | 101,364 | Mar. 29, 1870 | F 1, II |
| Hill, S. & Thumm, C. F. | 101,365 | Mar. 29, 1870 | F 1, II |
| Hill, S. & Thumm, C. F. | 102,819 | May 10, 1870 | F 1, II |
| Hill, S. & Thumm, C. F. | 114,293 | May 2, 1871 | F 1, 3, II |
| Hirshberg, Leon | 1,042,915 | Oct. 29, 1912 | D |
| Hirt, Leon E. | 1,222,402 | Apr. 10, 1917 | B, P |
| Hirt, L. E. | 1,250,879 | Dec. 18, 1917 | B, P |
| Hirt, L. E. | 1,264,796 | Apr. 30, 1918 | K, 3 |
| Holmes, F. W. & Blasdell, E. | 1,055,747 | Mar. 11, 1913 | B |
| Hodkinson, M | 26,326 | Nov. 29, 1859 | G, W |
| Hofferberth, John | 105,683 | July 26, 1870 | F 1, I |
| Hoffman, Bernhard | 641,962 | Jan. 23, 1900 | M |
| Hoffman, Ross J. | 405,738 | June 25, 1889 | S |
| Holmes, Jos. E. | 23,427 | Mar. 29, 1859 | G, W |
| Holmes, Jos. E. | 1,241,979 | Oct. 2, 1917 | B, J |
| Holmes, J. E. | 24,212 | May 31, 1859 | W |
| Hood, J. J. & Salamon, A. G. | 962,840 | June 28, 1910 | D 2 |
| Hopkins, A. S. | 1,199,463 | Sept. 26, 1916 | B |
| Hopkins, A. S. | 1,199,464 | Sept. 26, 1916 | B |
| Horner, E. N. | 22,727 | Jan. 25, 1859 | W, D |
| Houlker, Christopher | 110,364 | Dec. 20, 1870 | O |
| Howard, F. A. | 1,284,687 | Nov. 12, 1918 | F |
| Howarth, John | 42,772 | May 17, 1864 | W, F |
| Howe, Ephriam | 7,667 | Sept. 24, 1850 | M |
| Howell, —— | 1,294,909 | Feb. 18, 1919 | S |
| Howell, C. G. | 66,841 | July 16, 1867 | F 1, 2 |
| Howell, H. F. | 216,518 | June 17, 1879 | L |
| Hudson, Chas. R. | 681,170 | Aug. 20, 1901 | A |
| Hudson, Samuel | 123,907 | Feb. 20, 1872 | G |
| Huglo, Victor. | 953,952 | Apr. 5, 1910 | B |
| Hout, F. & Rogers, John | 71,619 | Nov. 15, 1867 | F 4 |
| Hout, F. & Rogers, John | 63,051 | Sept. 19, 1866 | S |
| Humason, G. A. | 1,291,899 | Jan. 21, 1919 | S |
| Humphreys, R. E. | 1,122,002 | Dec. 22, 1914 | B, S |
| Humphreys, R. E. | 1,122,003 | Dec. 22, 1914 | B |
| Humphreys, R. E. | 1,119,700 | Dec. 1, 1914 | B |
| Humphreys, R. E. | 1,286,179 | Nov. 26, 1918 | I |
| Huntington, John. | 62,750 | Mar. 12, 1867 | F |
| Huston, John B. | 297,603 | Apr. 29, 1884 | S |
| Huston, John B. | 486,406 | Nov. 15, 1892 | V |
| Hyde, Burrows. | 281,999 | July 24, 1883 | T |
| Hall, Wm. A. | 1,242,746 | Oct. 9, 1917 | B |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Hall, Wm. A. | 1,242,795 | Oct. 9, 1917 | B |
| Holmes, Fletcher B. | 1,276,219 | Aug. 20, 1918 | D |
| Hussey, John S. | 1,277,935 | Sept. 3, 1918 | C |
| Ihart, J. P. | 654,258 | July 24, 1900 | A |
| Ilges, T. W. | 968,478 | Aug. 23, 1910 | F 2, II |
| Isom, Edward W. | 1,285,200 | Nov. 19, 1918 | B |
| Jaeger, W. G. W. | 24,217 | May 31, 1859 | W |
| Jaeger, W. G. W. | 24,561 | June 28, 1859 | W, S |
| Jaeger, W. G. W. | 54,358 | Apr. 16, 1866 | F 1, 2, II |
| James, C. M. | 86,232 | Jan. 26, 1869 | F 1, 2, II |
| Jann, John. | 52,574 | Feb. 13, 1866 | M |
| Jann, John. | 57,727 | Sept. 4, 1866 | M |
| Jenkins, U. S. | 1,226,526 | May 15, 1917 | J, B |
| Jennings, Isaiah. | 1,453 | Dec. 31, 1839 | M |
| Jenney, W. P. | 190,762 | May 15, 1877 | I |
| Jenney, W. P. | 178,061 | May 30, 1876 | I |
| Jenney, W. P. | 178,154 | May 30, 1876 | I, T |
| Jensen, J. O. | 1,268,721 | June 4, 1918 | A |
| Johnson, John. | 54,917 | May 22, 1866 | S |
| Johnson & Snodgrass | 1,283,202 | Oct. 29, 1918 | S |
| Johnston, Jas. J. | 117,425 | July 25, 1871 | F |
| Johnston, Jas. J. | 117,426 | July 25, 1871 | A |
| Johnston, Jas. J. | 48,285 | June 20, 1865 | F 4, 5 |
| Johnston, Jas. J. | 31,982 | Apr. 9, 1861 | S |
| Johnston, Jas. J. | 50,935 | Nov. 14, 1865 | F 2 |
| Johnston, Jas. J. | 91,448 | June 15, 1869 | F 2, II |
| Jones, Philip. | 1,255,018 | Jan. 29, 1918 | K 2, S |
| Jones, E. C. & Jones, L. B. | 1,089,926 | Mar. 10, 1914 | K 1, 2 |
| Jones & Jones | 1,157,225 | Oct. 19, 1915 | K 1 |
| Jones, R. G. | 1,166,375 | Dec. 28, 1915 | F 2, II |
| Jones, R. G. | 1,005,977 | Oct. 17, 1911 | A |
| Jordery, Chas. A. | 126,552 | May 7, 1872 | M |
| Just, John A. | 658,988 | Oct. 2, 1900 | M |
| Kasson, H. R. & Saxton, S. S. | 998,691 | Apr. 7, 1914 | E 1, 2 |
| Kattell, E. C. | 222,408 | Dec. 9, 1879 | F 2, 4 |
| Kaysar, Adolf. | 508,479 | Nov. 14, 1893 | D 1, V |
| Kaysar, A. | 640,918 | Jan. 9, 1900 | V, D 1 |
| Keen, Morris L. | 25,552 | Sept. 20, 1859 | F 1 |
| Kelley, E. G. | 67,988 | Aug. 20, 1867 | F 1, II |
| Kelley, E. G. & Tait, A. H. | 32,568 | June 19, 1861 | F 1, 2, II |
| Kelley, E. G. | 84,195 | Nov. 17, 1868 | F 1, II |
| Kells, Edw. | 298,210 | May 6, 1884 | F |
| Kells, Edw. | 374,838 | Dec. 13, 1887 | F 1, I |
| Kelsey, S. E. | 1,092,366 | Apr. 7, 1914 | B |
| Kelsey, S. E. | 1,302,669 | May 6, 1919 | S |
| Kendall, Edw. D. | 413,187 | Oct. 22, 1889 | D |
| Kendall, Edw. D. | 359,357 | Mar. 15, 1887 | D 1 |
| Kendall, Edw. D. | 284,437 | Sept. 4, 1883 | D, M |
| Kendall, Edw. D. | 451,660 | May 5, 1891 | D 1, 2 |
| Kendall, Edw. D. | 1,192,529 | July 25, 1916 | K 2, J |
| Kendall, Edw. D. | 1,154,517 | Sept. 21, 1915 | D 1, S |
| Kendall, Edw. D. | 1,154,516 | Sept. 21, 1915 | D 1 |
| Kennedy, D. McD. | 370,950 | Oct. 4, 1887 | V |
| Kerr, A. N. | 1,199,903 | Oct. 3, 1916 | J |
| Keyt, M. H. | 1,262,808 | Apr. 16, 1918 | D |
| Kipper, H. B. | 1,253,048 | Jan. 8, 1918 | D 1 |
| Kirchhoffer, G. W. | 32,373 | May 21, 1861 | G, W |
| Kirk, Arthur. | 78,878 | June 16, 1868 | F 1, II |
| Kirk, J. L. | 215,756 | May 27, 1879 | F 1, II |
| Kirk, Solomon W. | 267,752 | Nov. 21, 1882 | C |
| Kirschbraun, L. | 1,194,750 | Oct. 3, 1916 | E 1, 2 |
| Kitchen, J. M. W. | 1,008,273 | Aug. 15, 1916 | F 1, 2, II |
| Klein, John S. | 306,837 | Oct. 21, 1884 | S |
| Kline, Geo. H. | 353,362 | Nov. 30, 1886 | F 1, II, S |
| Klosterman, Robt. | 152,650 | June 30, 1874 | F |
| Knottenbelt, H. W. | 1,194,033 | Aug. 8, 1916 | W |
| Knottenbelt, H. W. | 1,277,605 | Sept. 3, 1918 | D 1 |
| Koehler, Herman. | 507,441 | Oct. 24, 1893 | V |
| Koehler, W. C. & Link, L. | 1,084,016 | Jan. 13, 1914 | O |

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| Name | Number | Date | Class |
|---|---|---|---|
| Koppers, H. | 1,098,734 | June 2, 1914 | F 2, II |
| Kreiser, J. M. | 384,768 | June 19, 1888 | S |
| Kreiser, J. M. | 366,487 | July 12, 1887 | F |
| Kreusler, A. | 50,368 | Oct. 10, 1865 | F |
| Lacy, B. S. | 1,263,906 | Apr. 23, 1918 | L |
| Lackmen, A. | 1,171,524 | Feb. 15, 1916 | F 2, II |
| Laing, John. | 471,291 | Mar. 22, 1892 | B |
| Laing, John. | 488,767 | Dec. 27, 1892 | B |
| Laird, Robt. H. | 507,230 | Oct. 24, 1893 | F 2, II |
| Laird, Robt. H. | 498,518 | May 30, 1893 | F |
| Laird, R. E. & Raney, Jos. H. | 1,116,299 | Nov. 3, 1914 | A, P |
| Laird & Raney | 1,142,761 | June 8, 1915 | A, P |
| Laird & Raney | 1,142,760 | June 8, 1915 | A, P |
| Laird & Raney | 1,142,759 | June 8, 1915 | A, P |
| Lamb, D. M. | 183,401 | Oct. 17, 1876 | D 1 |
| Lambe, Frederick. | 102,135 | Apr. 19, 1870 | C |
| Lambert, Chas. G. | 1,245,930 | Nov. 6, 1917 | B |
| Lamplough, F. | 1,229,098 | June 5, 1917 | B |
| Landes, Wm. | 1,199,909 | Oct. 3, 1916 | B |
| Landsberg, L. | 1,211,721 | Jan. 9, 1917 | I |
| Lane, Edw. | 172,131 | Jan. 11, 1876 | F 1, II |
| Lang, J. S. | 954,575 | Apr. 12, 1910 | B |
| Lapham, Allen. | 59,317 | Oct. 30, 1866 | F |
| Lapp, C. E. | 1,266,281 | May 14, 1918 | B |
| Lasher, D. F. | 1,075,481 | Oct. 14, 1913 | D 1 |
| Lee, A. K. | 162,394 | Apr. 20, 1875 | E 1 |
| Leete, H. C. | 1,288,934 | Dec. 24, 1918 | D |
| Leman, Wm. T. | 727,391 | May 5, 1903 | U |
| Lennard, F. | 459,123 | Sept. 8, 1891 | F 2, II |
| Lennard, F. | 499,557 | June 13, 1893 | F 2 |
| Lennard, F. | 659,076 | Oct. 2, 1900 | T |
| Lepley, Clyde E. | 1,261,410 | Apr. 2, 1918 | F |
| Leslie, E. H. | 1,310,164 | July 15, 1919 | S |
| Lessing, Rudolf. | 1,281,597 | Oct. 15, 1918 | K 2 |
| Letchford, R. M. & Nation, W. | 133,042 | Nov. 12, 1872 | C |
| Levy, E. D. & Jacobs, H. W. | 1,251,978 | Jan. 1, 1918 | Q |
| Lewis, Sylvester. | 35,527 | June 10, 1862 | M |
| Lewis, S. | 42,671 | May 10, 1864 | V |
| Lewis, S. | 43,156 | June 14, 1864 | M |
| Lindenberg, G. & Scott, W. B. | 1,220,651 | Mar. 27, 1917 | K 2, B |
| Lindsey, Wm. J. | 1,256,340 | Feb. 12, 1918 | K 1 |
| Linn, S. S. | 1,284,117 | Nov. 5, 1918 | M |
| Livesay, Jas. & Kidd, Jas. | 258,778 | May 30, 1882 | F |
| Livingston, Julius I. | 239,260 | Mar. 22, 1881 | T |
| Livingston, Max. | 237,560 | Feb. 8, 1881 | F |
| Livingston, Max. | 728,257 | May 19, 1903 | F II |
| Lockhart, Chas. & Gracie, J. | 40,632 | Nov. 17, 1863 | F |
| Lockhart & Gracie | 80,294 | July 28, 1868 | F |
| Loew, Oscar. | 101,284 | Mar. 29, 1870 | D 1 |
| Lofhjelm, Karl. | 546,018 | Sept. 10, 1895 | F |
| Loftus, Robt. G. | 113,782 | Apr. 18, 1871 | D 1 |
| Loftus, Robt. G. | 81,654 | Sept. 1, 1868 | K 2 |
| Loftus, Robt. G. | 43,157 | June 14, 1864 | I |
| Long, F. R. | 1,256,146 | Feb. 12, 1918 | S |
| Loomis, C. C. | 1,280,612 | Oct. 1, 1918 | L |
| Loomis, Wells, Hitchcock & Stryker. | 66,364 | July 2, 1867 | M |
| Looney, John J. | 139,009 | May 20, 1873 | D 1 |
| Lorch, H. D. | 1,264,668 | Apr. 30, 1918 | F 2, 5 |
| Lossen, Clemens. | 537,121 | Apr. 9, 1895 | V |
| Low, Frank S. | 1,192,653 | July 25, 1916 | J, B |
| Lowe, W. P. & Bilfinger, C. W. | 556,155 | Mar. 10, 1896 | B |
| Lucas, Owen D. | 1,168,404 | Jan. 18, 1916 | B |
| Lucas, Owen D. | 1,183,091 | May 16, 1916 | B |
| Lugo, Orazio. | 51,843 | Jan. 2, 1866 | F 3 |
| Lugo, Orazio. | 60,757 | Jan. 1, 1867 | V, D 1 |
| Lugo, Orazio. | 58,113 | Sept. 18, 1866 | F 3, 4, I |
| Lugo, O. & Schrader, T. O. L. | 60,396 | Dec. 11, 1866 | F 3, 4, I |
| Lupton, George. | 110,054 | Dec. 13, 1870 | D |
| Lutz, H. E. | 240,914 | May 3, 1881 | F 1, II |

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| Name | Number | Date | Class |
|---|---|---|---|
| Maag, G. C. | 1,142,525 | June 8, 1915 | B |
| McAfee, Almer M. | 1,277,092 | Aug. 27, 1918 | C |
| McAfee, A. M. | 1,099,096 | June 2, 1914 | B |
| McAfee, A. M. | 1,127,465 | Feb. 9, 1915 | B |
| McAfee, A. M. | 1,144,304 | June 22, 1915 | B |
| McAfee, A. M. | 1,202,081 | Oct. 24, 1916 | B |
| McAfee, A. M. | 1,277,329 | Aug. 27, 1918 | D |
| McAfee, A. M. | 1,277,328 | Aug. 27, 1918 | D |
| McAfee, A. M. | 1,235,523 | July 31, 1917 | B |
| McArthur, D. R. | 1,119,974 | Dec. 8, 1914 | B |
| McCaig, D. C. | 1,255,449 | Feb. 5, 1918 | S |
| McCarty, F. | 91,953 | June 29, 1869 | F 2, II |
| McCarty, Wm. F. M. | 1,274,912 | Aug. 6, 1918 | B |
| McCarty, W. F. M. | 1,274,913 | Aug. 6, 1918 | B |
| McCue, J. & W. B. | 21,143 | Aug. 10, 1858 | W |
| McElroy, Karl P. | 1,259,757 | Mar. 19, 1918 | K 2, B |
| McElroy, Karl P. | 1,259,758 | Mar. 19, 1918 | K 2 |
| McGowan, Thompson. | 492,421 | Feb. 28, 1893 | F |
| McGowan, T. | 454,061 | June 16, 1891 | F |
| McGowan, T. | 443,328 | Dec. 23, 1890 | F |
| McGowan, T. | 658,857 | Oct. 2, 1900 | V |
| McGowan, T. | 257,961 | May 16, 1882 | F 3, D 1 |
| McGowan, T. | 431,386 | July 1, 1890 | F |
| McGowan, T. | 166,285 | Aug. 3, 1875 | F 2 |
| McGowan, T. | 492,419 | Feb. 28, 1893 | S |
| McGowan & Van Syckel, S. | 154,700 | Sept. 1, 1874 | S |
| McGowan & Van Syckel | 156,229 | Oct. 27, 1874 | F 1 |
| McHenry, C. D. | 1,154,869 | Sept. 28, 1915 | B, K 1 |
| McKee, Ralph H. | 1,244,444 | Oct. 23, 1917 | L |
| McKibben, C. W. | 1,299,589 | Apr. 8, 1919 | A |
| McKibben C. W. | 1,299,590 | Apr. 8, 1919 | A |
| McKissack, R. I. | 1,113,029 | Oct. 6, 1914 | K 1 |
| McManus, H. | 305,097 | Sept. 16, 1884 | I |
| McMillan, F. M. | 215,471 | May 20, 1879 | C |
| Macalpine, Thos. | 655,500 | Aug. 7, 1900 | D 1, 2 |
| Macalpine, Thos. | 686,663 | Nov. 12, 1901 | D 1, 2 |
| Macalpine, Thos. | 664,813 | Dec. 25, 1900 | F 2, 5, I |
| Macalpine, Thos. | 741,517 | Oct. 13, 1903 | D |
| Maitland, H. T. | 1,188,961 | June 27, 1916 | O, D |
| Maitland, H. T. | 1,272,979 | July 16, 1918 | D 1 |
| Mann, F. W. | 619,593 | Feb. 14, 1899 | B |
| Mann & Chappell, M. L. | 1,163,025 | Dec. 7, 1915 | D |
| Mann & Chappell | 1,183,094 | May 16, 1916 | L |
| Mann & Chappell | 1,214,204 | Jan. 30, 1917 | B |
| Mann & Chappell | 1,249,444 | Dec. 11, 1917 | B |
| Mann & Chappell | 1,257,906 | Feb. 26, 1918 | B |
| Mann, Stephen S. | 204,235 | May 28, 1878 | N |
| Mann, Stephen S. | 152,855 | July 7, 1874 | N |
| Mansfield, David. | 55,880 | June 26, 1866 | M |
| Marrin, Thos. | 211,762 | Jan. 28, 1879 | C |
| Marrin, Thos. | 243,930 | July 5, 1881 | F |
| Martin, J. N. | 254,990 | Mar. 14, 1882 | F |
| Martini, Dan. | 892,378 | June 30, 1908 | B, P |
| Mason, Allan. | 444,203 | Jan. 6, 1891 | F 1, 2, II |
| Mason, Allan. | 444,202 | Jan. 6, 1891 | F 1, 2, II |
| Mason, F. B. | 1,294,136 | Feb. 11, 1919 | M |
| Mathieu, Jean A. | 374,077 | Nov. 29, 1887 | F 2, 5, II |
| Mavbury, Wm. | 737,756 | Sept. 1, 1903 | F 1, 2, II |
| Meeds, Wilber R. | 266,859 | Oct. 31, 1882 | M |
| Meeds, W. R. | 250,830 | Dec. 13, 1881 | M |
| Meigher, Jas. D. | 224,301 | Feb. 10, 1880 | F 1, 4, II |
| Mellen, G. H. & Hazelton, J. C. | 57,749 | Sept. 4, 1866 | M |
| Mengel, Chas. C. | 116,852 | July 11, 1871 | F |
| Mengel, C. C. | 465,703 | Dec. 22, 1891 | F 1, 3 |
| Mengel, C. C. | 452,578 | May 19, 1891 | F 3, V |
| Meredith, S. | 13,358 | July 31, 1855 | W |
| Merrick, Thos. E. | 91,654 | June 22, 1869 | O, D |
| Merriam, E. S. | 1,304,587 | May 27, 1919 | J-K |
| Merriam, J. B. | 61,946 | Feb. 12, 1867 | C |

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| Name | Number | Date | Class |
|---|---|---|---|
| Merrill, Francis B. | 761,315 | May 31, 1904 | F |
| Merrill, Joshua. | 33,955 | Dec. 17, 1861 | S |
| Merrill, Joshua. | 32,951 | July 30, 1861 | S |
| Merrill, Joshua. | 32,706 | July 2, 1861 | S |
| Merrill, Joshua. | 32,704 | July 2, 1861 | D 1 |
| Miller, J. R. | 1,312,265 | Aug. 5, 1919 | B |
| Merrill, Joshua. | 32,705 | July 2, 1861 | D 1 |
| Merrill, Joshua. | 90,284 | May 18, 1869 | F 1, 2 |
| Merrill, Joshua. | 43,325 | June 28, 1864 | D 1 |
| Merrill, Willis C. | 1,252,376 | Jan. 1, 1918 | E 3 |
| Mertz, Josef. | 339,201 | Apr. 6, 1886 | F 2, II |
| Mesereau, G. | 1,282,906 | Oct. 29, 1918 | K |
| Mesereau, G. | 1,308,802 | July 8, 1919 | K |
| Meucci, Antonio. | 36,419 | Sept. 9, 1862 | D 1 |
| Midgely, T., Jr. | 1,296,832 | Mar. 11, 1919 | M |
| Mijs, Jan. | 1,178,532 | Apr. 11, 1916 | C |
| Miles, George. | 205,407 | June 25, 1878 | F, S |
| Miles, George W. | 1,168,534 | Jan. 18, 1916 | C |
| Miller, Jas. | 77,070 | Apr. 21, 1868 | F 5, II |
| Millochau, Adolph. | 38,641 | May 19, 1863 | D 1 |
| Millochau, A. | 37,918 | Mar. 17, 1863 | D 1 |
| Millochau, A. | 53,167 | Mar. 13, 1866 | F 1 |
| Millochau, A. | 46,923 | Mar. 21, 1865 | F 1 |
| Millochau, A. | 41,085 | Jan. 5, 1864 | D 1 |
| Millochau, A. | 49,777 | Sept. 5, 1865 | N |
| Mills, E. N. | 1,007,788 | Nov. 7, 1911 | Q |
| Millspaugh, Pethuel. | 127,259 | May 28, 1872 | N |
| Mims, John C. | 713,475 | Nov. 11, 1902 | D 1, E 3 |
| Minshall, F. W. | 514,876 | Nov. 26, 1889 | F 2, 3, V |
| Mitchell, Willis. | 1,141,072 | May 25, 1915 | K 1 |
| Montague, H. E. | 1,227,551 | May 22, 1917 | B |
| Mooney, L. | 1,174,888 | Mar. 7, 1916 | R |
| Moore, E. A. | 786,828 | Apr. 11, 1905 | A |
| Moore, George H. | 586,520 | July 13, 1897 | V, D 1 |
| Moore, E. S. & Thomas, H. H. | 1,281,808 | Oct. 15, 1918 | S |
| Moore, J. B. | 1,130,318 | Mar. 2, 1915 | B |
| Morehouse, C. L. | 55,426 | June 5, 1866 | D 1, C |
| Morehouse, C. L. | 174,921 | Mar. 21, 1876 | G |
| Morfit, Clarence. | 66,243 | July 2, 1867 | U |
| Morris, W. L. | 1,137,075 | Apr. 27, 1915 | C |
| Morris, W. L. | 1,305,735 | June 3, 1919 | O |
| Mott, Leander M. | 54,192 | Apr. 24, 1866 | O |
| Mowbray, George M. | 25,575 | Sept. 27, 1859 | F 1, 4, II |
| Munson, A. L. | 440,830 | Nov. 18, 1890 | D |
| Murray, Thos. E. | 1,273,523 | July 23, 1918 | S |
| Murray, T. E. and Ricketts, E. B. | 1,293,866 | Feb. 11, 1919 | F |
| Mueller, C. L. E. | 1,297,388 | Mar. 18, 1919 | M |
| Murray, T. E. | 1,302,200 | Apr. 29, 1919 | S |
| Myers, Geo. W. | 147,783 | Feb. 24, 1874 | K 2, S |
| Navin, F. | 1,312,266 | Aug. 5, 1919 | W |
| Neahous, Herman. | 242,554 | June 7, 1881 | C |
| Neal, Stephens. | 1,036,306 | Aug. 20, 1912 | F 2 |
| Neilson, Albert. | 239,618 | Apr. 5, 1881 | F |
| Newall, Robert. | 53,656 | Apr. 3, 1866 | V, D |
| Newsome, Thos. J. | 405,047 | June 11, 1889 | A |
| Nichols, H. M. | 1,302,832 | May 6, 1919 | S |
| Nicholson, John. | 22,973 | Feb. 15, 1859 | W |
| Nicolai, J. H. & W. F. | 224,037 | Feb. 3, 1880 | G, S |
| Nicolai, Pierre. | 225,635 | Mar. 16, 1880 | F 2 |
| Nikiforoff, A. | 755,309 | Mar. 22, 1904 | B |
| Noad, James. | 971,468 | Sept. 27, 1910 | B |
| Noad, Jas. | 985,053 | Feb. 21, 1911 | B, W |
| Nordenson, Carl O. | 1,218,575 | Mar. 6, 1917 | K 1 |
| Norton, J. W. & Rouse, F. H. | 313,514 | Mar. 10, 1885 | S |
| Norton & Rouse | 336,941 | Mar. 2, 1886 | F 2, 4, D 1 |
| Noteman, Alonzo. | 512,894 | Jan. 16, 1894 | D |
| Noyes, John E. | 82,151 | Sept. 15, 1868 | G, M |
| Ogilvy, David J. | 1,268,142 | June 4. 1918 | W |
| O'Hara, Jas. | 22,573 | Jan. 11, 1859 | K 3 |

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| Name | Number | Date | Class |
|---|---|---|---|
| Olsen, Geo. E. | 1,199,491 | Sept. 26, 1916 | J, A |
| O'Neall, J. M. | 754,687 | Mar. 15, 1904 | F 1, 2, II |
| Opl, Karl. | 1,128,494 | Feb. 16, 1915 | C |
| Paine, Henry H. | 9,119 | July 13, 1852 | M |
| Palmer, Chas. S. | 1,187,380 | June 13, 1916 | B |
| Palmer, Chas. S. | 1,268,763 | June 4, 1918 | K 1 |
| Palmer, Chas. S. | 1,313,009 | Aug. 12, 1919 | B |
| Parker, J. H. | 958,820 | May 24, 1910 | B |
| Parker, R. B. | 1,252,481 | Jan. 8, 1918 | K 2 |
| Parker, W. C. | 169,189 | Oct. 26, 1875 | O |
| Parker, W. M. | 1,226,990 | May 22, 1917 | B |
| Parsons, Chas. C. | 88,978 | Apr. 13, 1869 | F 2, 5 |
| Parsons, C. Chauncey | 93,739 | Aug. 17, 1869 | C |
| Parsons, H. E. | 214,946 | Apr. 29, 1879 | F, K 2 |
| Pease, Francis S. | 226,187 | Apr. 6, 1880 | N |
| Pemberton, Henry. | 24,952 | Aug. 2, 1859 | W, I |
| Penissat, Andre. | 204,244 | May 28, 1878 | I |
| Perkins, A. H. | 36,632 | Oct. 7, 1862 | T |
| Perkins, George H. | 399,073 | Mar. 5, 1889 | F |
| Perkins, Geo. H. | 240,923 | May 3, 1881 | S |
| Perkins, J. & Burnet, Wm. H. | 47,125 | Apr. 4, 1865 | F 2, II |
| Perkins, W. D. | 731,943 | June 23, 1903 | F 1, 2, II |
| Perrier, Odilon. | 544,516 | Aug. 13, 1895 | F 1, 2, II |
| Perrine, Robt. M. | 419,347 | Jan. 14, 1890 | V, D |
| Peterson, F. P. | 1,031,664 | July 2, 1912 | J, K 2 |
| Petroff, Grigori. | 1,087,888 | Feb. 17, 1914 | I |
| Petroff, G. | 1,233,700 | July 17, 1917 | D 1 |
| Petty, T. K. & Warden, W. G. | 37,263 | Dec. 23, 1862 | S |
| Peuchen, S. C. | 531,560 | Dec. 25, 1894 | P |
| Pfeifer, F. | 1,296,115 | Mar. 4, 1919 | K |
| Pfeifer, F. | 1,296,116 | Mar. 4, 1919 | K |
| Philip, A. | 1,286,091 | Nov. 26, 1918 | Q |
| Phillipps, Joseph. | 98,883 | Jan. 18, 1870 | G, M |
| Pictet, Raoul P. | 1,228,818 | June 5, 1917 | B |
| Pielsticker, Carl M. | 186,951 | Feb. 6, 1877 | D 1 |
| Pielsticker, Carl M. | 477,153 | June 14, 1892 | F 2, II |
| Pijzel, Daniel. | 1,070,730 | Aug. 19, 1913 | C |
| Pinckney, T. De Witt | 221,421 | Nov. 11, 1879 | N |
| Pinkham, C. W. | 34,772 | Mar. 25, 1862 | M, G |
| Pine, J. A. W. & Ruggles, Wm. B. | 1,057,667 | Apr. 1, 1913 | E 3 |
| Pitt, Wm. H. | 379,492 | Mar. 13, 1888 | F, V |
| Pitt, Wm. H. | 411,394 | Sept. 17, 1889 | F, V |
| Place, Chas. T. | 243,080 | June 21, 1881 | F |
| Poisat, A. M. & Knab, D. C. | 7,124 | Feb. 26, 1850 | F 2, II |
| Pollak, R. R. | 1,254,271 | Jan. 22, 1918 | A |
| Ponton, John. | 165,612 | July 13, 1875 | N |
| Porges, P, & Neumann, R. | 1,017,587 | Feb. 13, 1912 | C |
| Porter, Alonzo W. | 146,778 | Jan. 27, 1874 | G |
| Poterie, George. | 453,386 | June 2, 1891 | W |
| Pray, Lyman. | 61,098 | Jan. 8, 1867 | S, F |
| Prentiss, E. F. & Robertson, R. A. | 48,435 | June 27, 1865 | U |
| Prentiss & Robertson | 41,858 | Mar. 8, 1864 | F 2, II |
| Price, C. P. | 1,273,091 | July 16, 1918 | F 2, 4 |
| Price, Walter B. | 548,391 | Oct. 22, 1895 | D 1 |
| Price, W. B. | 522,628 | June 26, 1894 | G, D 1 |
| Prichard, Geo. I. | 1,264,435 | Apr. 30, 1918 | F 2, II |
| Prichard, G. L. | 1,290,345 | Jan. 7, 1919 | I |
| Propfe, H. | 478,265 | July 5, 1892 | F 1, II |
| Prutzman, Paul W. | 1,238,331 | Aug. 28, 1917 | A |
| Puning, Franz. | 1,176,094 | Mar. 21, 1916 | K 2, S |
| Pyzel, Daniel. | 1,040,408 | Oct. 8, 1912 | C |
| Pyzel, Daniel. | 1,276,690 | Aug. 20, 1918 | S |
| Quinn, Abraham. | 31,998 | Apr. 9, 1861 | F |
| Quinn, A. | 36,481 | Sept. 16, 1862 | F |
| Rand, Alonzo C. | 62,362 | Feb. 26, 1867 | S |
| Rave, Chas. | 425,905 | Apr. 15, 1890 | I, P |
| Reese, Jacob. | 38,602 | May 19, 1863 | S |
| Reese, Jacob. | 150,614 | May 5, 1874 | S |
| Reeves, S. H. | 1,302,090 | Apr. 29, 1919 | T |

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| Name | Number | Date | Class |
|---|---|---|---|
| Reeves, W. P. | 1,283,559 | Nov. 5, 1918 | S |
| Reilly, P. C. | 1,310,164 | July 15, 1919 | F, S |
| Rensink, G. C. | 1,134,419 | Apr. 6, 1915 | A |
| Requa, Chas. W. | 77,094 | Apr. 21, 1868 | F 1, 2, I |
| Restieux, Thos. | 63,749 | Apr. 9, 1867 | V, D 1 |
| Reynolds, F. R. | 1,119,453 | Dec. 1, 1914 | F 2 |
| Rice, L. M. & Adams, S. E. | 90,392 | May 25, 1869 | S |
| Richardson, Clifford. | 551,294 | Dec. 10, 1895 | E 3, A |
| Richardson, Wm. D. | 1,257,397 | Feb. 26, 1918 | P |
| Richardson, John E. | 65,275 | May 28, 1867 | C |
| Richter, Felix. | 1,098,763 | June 2, 1914 | D |
| Richter, Felix. | 1,098,764 | June 2, 1914 | D |
| Rites, F. M. | 1,167,021 | Jan. 4, 1916 | K 1, B |
| Rites, F. M. | 1,144,788 | June 29, 1915 | K 1, B |
| Rites, F. M. | 1,144,789 | June 29, 1915 | K 1, B |
| Roake, John S. | 700,373 | May 20, 1902 | D 1 |
| Roberts, A. E. & Emery, A. L. | 1,016,958 | Feb. 13, 1912 | Q |
| Robertson, J. H. | 1,238,339 | Aug. 28, 1917 | B, P |
| Robinson, C. I. | 1,014,520 | Jan. 9, 1912 | I |
| Robinson, C. I. | 1,018,374 | Feb. 20, 1912 | F 1 |
| Robinson, C. I. | 968,692 | Aug. 30, 1910 | D 1 |
| Robinson, C. I. | 910,584 | Jan. 26, 1909 | V, D |
| Robinson, J. C. | 218,901 | Aug. 26, 1879 | F 2, II |
| Rodman, Hugh. | 1,209,336 | Dec. 19, 1916 | B |
| Rogers, Davenport. | 211,055 | Dec. 17, 1878 | F 2, 4, II |
| Rogers, D. | 284,331 | Sept. 4, 1883 | F |
| Rogers, F. M. | 1,299,385 | Apr. 1, 1919 | A |
| Rogers, Henry H. | 120,539 | Oct. 31, 1871 | F |
| Rogers, John. | 50,276 | Oct. 3, 1865 | F |
| Rogers, Lebbeus H. | 1,269,747 | June 18, 1918 | W |
| Rogers, F. M. & Cooke, T. S. | 1,122,220 | Dec. 22, 1914 | J |
| Rogers, M. C. | 1,148,990 | Aug. 3, 1915 | S |
| Rogers, Wm. B. | 60,559 | Dec. 18, 1866 | M |
| Roots, James. | 340,522 | Apr. 20, 1886 | M, G |
| Rose, H. C. | 182,775 | Oct. 3, 1876 | F 1, 2, II |
| Rose, James R. | 1,252,033 | Jan. 1, 1918 | B, K 1 |
| Rosen, Jean. | 1,165,909 | Dec. 28, 1915 | O |
| Rosen, Jean. | 1,162,654 | Nov. 30, 1915 | B |
| Ross, S. J. & Schofield, H. | 1,204,492 | Nov. 14, 1916 | B |
| Roth, P. & Venturino, M. E. | 1,208,378 | Dec. 12, 1916 | B |
| Roth & Venturino | 1,208,214 | Dec. 12, 1916 | B |
| Roth & Venturino | 1,208,378 | Dec. 12, 1916 | B |
| Rowlands, P. O. | 1,252,955 | Jan. 8, 1918 | S |
| Rowsell, John. | 299,167 | May 27, 1884 | D 1 |
| Ryder, Henry. | 142,515 | Sept. 2, 1873 | F, S |
| Ryder, Watson. | 214,199 | Apr. 8, 1879 | F 1, II |
| Ryder, W. & Qualey, J. A. | 739,957 | Sept. 22, 1903 | F |
| Rosenbaum, R. R. | 1,278,023 | Sept. 3, 1918 | C, E 2 |
| Ruff, F. C. | 1,263,289 | Apr. 16, 1918 | D 1 |
| Sabatier, P. & Mailhe, A. | 1,124,333 | Jan. 12, 1915 | B, P |
| Sabatier, P. & Mailhe, A. | 1,152,765 | Sept. 7, 1915 | B |
| Salathe, Frederick. | 452,764 | May 19, 1891 | T |
| Salathe, F. | 564,341 | July 21, 1896 | T |
| Sampson, C. E. & Woods, W. | 1,177,816 | Apr. 4, 1916 | B |
| Sangster, W. H. | 54,414 | May 1, 1866 | S, D |
| Sangster, W. H. & Spencer, T. C. | 56,276 | July 10, 1866 | F |
| Sargent, Thos. D. | 20,587 | June 15, 1858 | W |
| Savage, Wallace. | 1,279,918 | Sept. 24, 1918 | E 1 |
| Sawyer, G. T., Howland, W., Jr., & Hatch, T. C. | 33,905 | Dec. 10, 1861 | S |
| Saybolt, Geo M. | 565,039 | Aug. 4, 1896 | D 1 |
| Saybolt, G. M. | 565,040 | Aug. 4, 1896 | D 1 |
| Saybolt, G. M. | 989,827 | Apr. 18, 1911 | J, K 2 |
| Saybolt, G. M. | 218,066 | July 29, 1879 | N |
| Saybolt, G. M. | 245,568 | Aug. 9, 1881 | N |
| Schalk, Emil. | 146,405 | Jan. 13, 1874 | D |
| Schalk, Emil. | 133,598 | Dec. 3, 1872 | D, S |
| Schesch, H. A. | 54,218 | Apr. 24, 1866 | F |
| Scheuffgen, Robert. | 1,118,952 | Dec. 1, 1914 | H |

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| Name | Number | Date | Class |
|---|---|---|---|
| Schildhaus, G. & Condrea, C. | 956,184 | Apr. 26, 1910 | I |
| Schill, E. | 1,100,260 | June 16, 1914 | F, K 2 |
| Schill, E. | 1,142,275 | June 8, 1915 | J, K 2 |
| Schiller, Max. | 580,652 | Apr. 13, 1897 | V |
| Schmidt, A. T. | 164,694 | June 22, 1875 | D |
| Schmidt, W. A. and Wolcott, E. R. | 1,308,161 | June 24, 1919 | B |
| Schubert, Julius. | 156,600 | Nov. 3, 1874 | A |
| Schwartz, Stephen. | 1,247,883 | Nov. 27, 1917 | B |
| Scott, John B. | 58,180 | Sept. 18, 1866 | M |
| Seeger, Robert. | 1,259,786 | Mar. 19, 1918 | B |
| Seely, E. D. | 57,390 | Aug. 21, 1866 | M |
| Seely, C. A. | 87,207 | Feb. 23, 1869 | F |
| Seibert, F. M. and Brady, J. D. | 1,290,369 | Jan. 7, 1919 | A |
| Seidenschur, F. & Dehnst, J. | 1,162,729 | Nov. 30, 1915 | B |
| Seigle, A. | 567,751 | Sept. 15, 1896 | F 1, II |
| Seigle, A. | 567,752 | Sept. 15, 1896 | F |
| Sellers, H. L. & Conyngton, H. R. | 549,399 | Nov. 5, 1895 | E 3 |
| Setzler, H. B. | 1,292,966 | Jan. 28, 1919 | B |
| Sewell, B. F. Brooke | 781,045 | Jan. 31, 1905 | F |
| Sexton, Wm. A. | 1,248,730 | Dec. 4, 1917 | A |
| Seymour, M. J. | 306,965 | Oct. 21, 1884 | A |
| Shapter, J. S. | 61,474 | Jan. 22, 1867 | F 1, 2, 5 |
| Shaw, F. D. | 1,098,412 | June 2, 1914 | K 1 |
| Shaw, G. E. | 61,572 | Jan. 29, 1867 | N |
| Shaw, G. E. | 56,107 | July 3, 1866 | N |
| Sheets, Earl H. | 1,273,191 | July 23, 1918 | K 2, J |
| Sherman, L. O. | 968,088 | Aug. 23, 1910 | B |
| Sherman, L. O. | 1,260,584 | Mar. 26, 1918 | B, J |
| Sherman, L. O. | 1,288,711 | Dec. 24, 1918 | B |
| Shiner, O. J. | 1,099,622 | June 9, 1914 | D 1 |
| Shively, Martin. | 613,728 | Mar. 11, 1919 | S |
| Shreves, F. G. | 1,297,022 | Nov. 8, 1898 | A |
| Shroder, Richard. | 16,255 | Dec. 16, 1856 | W |
| Slater, Wm. A. | 1,263,950 | Apr. 23, 1918 | I |
| Skidmore, C. J. and Coventry, P. F. | 1,302,094 | Apr. 29, 1919 | O |
| Slemmer, Henry T. | 52,897 | Feb. 27, 1866 | O |
| Sloane, W. M. | 109,772 | Nov. 29, 1870 | A |
| Sloane, W. M. & Potter, R. M. | 223,549 | Jan. 13, 1880 | C |
| Sloane, W. M. & Bell, Wm. | 235,057 | Nov. 30, 1880 | C |
| Slocum, F. L. and Stutz, C. C. | 1,304,211 | May 20, 1919 | B |
| Slocum, F. L. and Stutz, C. C. | 1,304,212 | May 30, 1919 | B |
| Small, H. J. & Stillman, H. | 595,788 | Dec. 21, 1897 | D 1, F 2 |
| Smedley, J. D. | 37,709 | Feb. 17, 1863 | S |
| Smith, A. D. | 1,239,423 | Sept. 4, 1917 | J, B |
| Smith, C. A. | 558,747 | Apr. 21, 1896 | V, D |
| Smith, H. C. | 300,811 | June 24, 1884 | F II |
| Smith, Hamilton L. | 60,585 | Dec. 18, 1866 | S |
| Smith, H. L. | 60,076 | Nov. 27, 1866 | F 2, 4, I |
| Smith, H. J. & Jones, W. | 35,184 | May 6, 1852 | N |
| Smith, Rollin H. | 306,653 | Oct. 14, 1884 | C |
| Smith, Wm. | 23,119 | Apr. 19, 1850 | G, S |
| Smith, Wm. A. | 596,437 | Dec. 28, 1897 | V |
| Smothers, H. F. & Norquist, E. E. | 1,263,337 | May 14, 1918 | Q |
| Snee, J. A. | 1,165,568 | Dec. 28, 1915 | K 2 |
| Snelling, W. O. | 1,056,845 | Mar. 25, 1913 | J, K 2, B |
| Snelling, W. O. | 1,186,855 | June 13, 1916 | F 1 |
| Snelling, W. O. | 1,215,732 | Feb. 13, 1917 | V |
| Snow, Wm. B. | 130,668 | Aug. 20, 1872 | S |
| Snow, Wm. B. | 137,496 | Apr. 1, 1873 | S |
| Soderlund and Boberg | 1,252,962 | Jan. 18, 1918 | F 2 |
| Sommer, Adolph. | 525,969 | Sept. 11, 1894 | V |
| Sommer, A. | 523,716 | July 31, 1894 | V |
| Southey, A. W. | 1,120,857 | Dec. 15, 1914 | K 1 |
| Spangle, George W. | 58,905 | Oct. 16, 1866 | D |
| Spears, Wm. | 107,734 | Sept. 27, 1870 | F, G |
| Spier, Robert & Mather, J. | 168,060 | Sept. 21, 1875 | U |
| Speller, F. N. | 774,341 | Nov. 8, 1904 | N |
| Squires, Frederick. | 1,249,232 | Dec. 4, 1917 | J, K 2 |
| Squire, F. B. | 197,197 | Nov. 13, 1877 | N |

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| Name | Number | Date | Class |
|---|---|---|---|
| Stafford, Jas. R. | 10,813 | Apr. 25, 1854 | U |
| Starke, Eric A. | 597,920 | Jan. 25, 1898 | D 1 |
| Starke, E. A. | 781,240 | Jan. 31, 1905 | E 3, B |
| Stanley, A. M. | 1,177,904 | Apr. 4, 1916 | K 1 |
| Starke, E. A. | 913,780 | Mar. 2, 1909 | D, F 2 |
| Starke, E. A. | 1,109,187 | Sept. 1, 1914 | D 1 |
| Stearns, H. A. | 103,385 | May 24, 1870 | F 2, II |
| Steenbergh, B. van | 1,124,364 | Jan. 12, 1915 | K 1, B |
| Steinschneider, —— | 1,302,988 | May 6, 1919 | S |
| Steinschneider, Leo. | 981,953 | Jan. 17, 1911 | F 5 |
| Steinschneider, Leo. | 1,192,581 | July 25, 1916 | F 5 |
| Stelwagon, W. H. | 503,996 | Aug. 29, 1893 | S |
| Stevens, Levi. | 363,432 | May 24, 1887 | F 2 |
| Stevens, Levi. | 414,601 | Nov. 5. 1889 | B |
| Stevens, Wm. H. | 1,165,462 | Dec. 28, 1915 | M |
| Stewart, John L. | 24,587 | June 28, 1850 | W |
| Stewart, J. L. | 162,965 | May 4, 1875 | F 2, II |
| Stewart, J. L. & Logan, J. P. | 113,811 | Apr. 18, 1871 | F |
| Stewart, J. L. & Dubler, J. B. | 136,557 | Mar. 4, 1873 | S |
| Stewart, Lyman. | 1,163,570 | Dec. 7, 1915 | B |
| Still, Carl. | 1,080,177 | Dec. 2, 1913 | S |
| Stombs, D. S. & Brace, J. | 27,842 | Apr. 10, 1860 | G |
| Stone, C. W. | 1,070,555 | Aug. 19, 1913 | A |
| Stott, Chas. | 68,257 | Aug. 19, 1867 | F 1, 2 |
| Strache, H. & Porges, P. | 1,205,578 | Nov. 21, 1916 | B |
| Strain, E. W. | 311,543 | Feb. 3, 1883 | F 1, 2, II |
| Street, G. E. J. | 70,715 | Mar. 11, 1902 | M |
| Stringfellow, John H. W. | 454,777 | June 23, 1891 | D |
| Stuber, John, Stuber, Jacob & Mager, John W. | 123,741 | Feb. 13, 1872 | F 1, 2, II |
| Suckert, Julius J. | 534,295 | Feb. 19, 1895 | V |
| Suhr, C. L. | 1,122,169 | Dec. 22, 1914 | F 2, II |
| Swan, O. C. | 1,250,526 | Dec. 18, 1917 | A |
| Swan, O. C. | 1,283,945 | Nov. 12, 1918 | S |
| Swaton, J. A. | 1,260,731 | Mar. 26, 1918 | B |
| Sylvester, F. | 68,669 | Sept. 10, 1867 | A |
| Symmes, H. K. | 26,000 | Nov. 1, 1859 | G |
| Symonds, D. | 65,136 | May 28, 1867 | V |
| Symonds, D. | 65,137 | May 28, 1867 | V |
| Tagliabue, Chas. J. | 265,462 | Oct. 3, 1882 | F 1, 2, 3, 4, II |
| Tagliabue, Chas. J. | 254,176 | Feb. 28, 1882 | F 1, 2, II |
| Tagliabue, Giuseppe. | 36,826 | Oct. 28, 1862 | N |
| Tagliabue, Chas. J. | 1,263,145 | Apr. 16, 1918 | N |
| Tagliabue, Giuseppe. | 38,427 | May 5, 1863 | N |
| Tagliabue, John. | 36,488 | Sept. 16, 1862 | N |
| Tait, A. H. | 96,997 | Nov. 16, 1869 | S |
| Tait, E. W. | 1,069,908 | Aug. 12, 1913 | J, K 2 |
| Tait, G. M. S. | 1,128,549 | Feb. 16, 1915 | K 1, B |
| Tait, A. H. & Avis, J. W. | 53,359 | Mar. 20, 1866 | F 2, 3, II |
| Tait & Avis. | 63,115 | Mar. 19, 1867 | F 1 |
| Tait & Avis. | 135,673 | Feb. 11, 1873 | F 2, II |
| Tatro, Jos. A. | 99,728 | Feb. 8, 1870 | D 1 |
| Tatro, Jos. A. | 106,233 | Aug. 9, 1870 | D 1 |
| Taveau, Rene de M. | 1,271,387 | July 2, 1918 | I, E 1 |
| Taylor, H. K. & Graham, D. M. | 54,978 | May 22, 1866 | D 1 |
| Taylor & Graham | 59,751 | Nov. 20, 1866 | D 1 |
| Tempere, Albert J. | 557,291 | Mar. 31, 1896 | V, D |
| Testelin, A. & Rehard, G. | 1,138,260 | May 4, 1915 | B |
| Theisen, Eduard. | 552,456 | Dec. 31, 1895 | F |
| Theisen, Eduard. | 552,455 | Dec. 31, 1895 | F |
| Thiele, Felix C. | 683,354 | Sept. 24, 1901 | D 1 |
| Thiele, Felix Carl. | 1,254,866 | Jan. 29, 1918 | L |
| Thirault, A. | 61,120 | Jan. 8, 1867 | F 4, II |
| Thirault, A. | 41,871 | Mar. 8, 1864 | |
| Thirault, A. | 63,963 | Apr. 16, 1867 | F 2 |
| Thomas, John J. | 178,889 | June 20, 1876 | S |
| Thomas, Joshua. | 282,239 | July 31, 1883 | F II |
| Thomas, Joshua. | 314,490 | Mar. 24, 1885 | F 2 |
| Thomas, Richard. | 781,854 | Feb. 7, 1905 | S |
| Thompson, W. P. | 1,160,670 | Nov. 16, 1915 | B |

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| Name | Number | Date | Class |
|---|---|---|---|
| Thumm, Chas. F. | 389,988 | Sept. 25, 1888 | F 2, 4 |
| Thursby, John. | 3,067 | May 2, 1843 | M |
| Tiemann, Julius H. | 321,465 | July 7, 1885 | D 1 |
| Tiemann, J. H. | 330,637 | Nov. 17, 1885 | D 1 |
| Tienen, W. O. Th. van | 1,000,646 | Aug. 15, 1911 | I |
| Timmons, J. R. | 1,105,383 | July 28, 1914 | F 1, II |
| Timmons & Swain, O. | 1,179,243 | Apr. 11, 1916 | F 1 |
| Tilton, Ole. | 204,943 | Nov. 12, 1878 | F 2, 4 |
| Timmons, J. R. | 1,279,611 | Sept. 24, 1918 | A |
| Tokheim, J. J. | 1,248,951 | Dec. 4, 1917 | A |
| Toppan, Chas. | 498,588 | May 30, 1893 | D |
| Travers, W. J. | 1,004,219 | Sept. 26, 1911 | A |
| Trewby, G. C. & Fenner, H. W. | 252,981 | Jan. 31, 1882 | F 2 |
| Trumble, Milton J. | 996,736 | July 4, 1911 | S, F |
| Trumble, M. J. | 1,002,474 | Sept. 5, 1911 | F 1, II |
| Trumble, M. J. | 1,070,361 | Aug. 12, 1913 | F 2, II |
| Trumble, M. J. | 1,182,601 | May 9, 1916 | E 2, F 2, II |
| Trumble, M. J. | 1,250,052 | Dec. 11, 1917 | F, S |
| Trumble, M. J. | 1,259,171 | Mar. 12, 1918 | F 2, A |
| Trumble, M. J. | 1,260,598 | Mar. 26, 1918 | F |
| Trumble, M. J. | 1,262,875 | Apr. 16, 1918 | F |
| Trumble, M. J. | 1,269,134 | June 11, 1918 | K 2, S |
| Turner, C. W. | 1,046,683 | Dec. 10, 1912 | B |
| Turner, C. W. | 1,151,422 | Aug. 24, 1915 | B |
| Turner, R. D. | 194,275 | Aug. 14, 1877 | A, V |
| Thompson, N. W. | 1,298,602 | Mar. 25, 1919 | S |
| Trumble, M. J. | 1,304,125 | May 20, 1919 | B |
| Trumble, M. J. | 1,304,124 | May 20, 1919 | A |
| Trumble, M. J. | 1,281,884 | Oct. 15, 1918 | B |
| Turner, R. D. | 154,430 | Aug. 25, 1874 | A |
| Turner, R. D. | 156,899 | Nov. 17, 1874 | S, F |
| Tweddle, Herbert W. C. | 120,349 | Oct. 24, 1871 | D |
| Tweddle, H. W. C. | 189,401 | Apr. 10, 1877 | T |
| Tweddle, H. W. C. | 189,402 | Apr. 10, 1877 | T |
| Tweddle, H. W. C. | 45,363 | Dec. 6, 1864 | K 2 |
| Tweddle, H. W. C. | 72,125 | Dec. 10, 1867 | F 2, 5, II |
| Tweddle, H. W. C. | 72,126 | Dec. 10, 1867 | F 2, 5, II |
| Tweddle, H. W. C. | 34,324 | Feb. 4, 1862 | G, F 2, 5, II |
| Tyler, Chas. N. | 38,015 | Mar. 24, 1863 | M |
| Ujhely, Heinrich. | 289,788 | Dec. 4, 1883 | D |
| Ujhely, H. & Buerle, C. | 131,137 | Sept. 3, 1872 | C |
| Upham, Richard D. | 512,494 | Jan. 9, 1894 | E 3 |
| Van Devort, C. & Van Fleet, C. | 168,542 | Oct. 5, 1875 | F 2 |
| Van Dyke, J. & Irish, Wm. | 1,095,438 | May 5, 1914 | B |
| Van Dyke & Irish. | 1,073,548 | Sept. 16, 1913 | B |
| Van Dyke & Irish. | 1,143,466 | June 15, 1915 | B |
| Van Dyke & Irish. | 1,130,862 | Mar. 9, 1915 | B |
| Van Vliet, L. & O'Neil, F. | 1,094,762 | Apr. 28, 1914 | K 1 |
| Vander Weyde, Peter H. | 104,798 | June 28, 1870 | N |
| Vander Weyde, P. H. | 61,125 | Jan. 8, 1867 | A |
| Vander Weyde, P. H. | 58,005 | Sept. 11, 1866 | F 2, 4, 5, II |
| Vander Weyde, P. H. | 58,512 | Oct. 2, 1866 | F |
| Vander Weyde, P. H. | 53,062 | Mar. 6. 1866 | F |
| Van Syckel, Samuel. | 191,203 | May 22, 1877 | F, II |
| Van Syckel, S. | 140,801 | July 15, 1873 | F 2 |
| Van Syckel, S. | 152,440 | June 23, 1874 | F, II |
| Van Syckel, S. | 126,503 | May 7, 1872 | S |
| Van Syckel, S. | 154,772 | Sept. 8, 1874 | F, II |
| Van Syckel, S. | 154,771 | Sept. 8, 1874 | U |
| Van Syckel, S. | 143,945 | Oct. 21, 1873 | K 2 |
| Van Syckel, S. | 110,516 | Dec. 27, 1870 | F 2, I |
| Van Syckel, S. | 191,204 | May 22, 1877 | F, II |
| Van Tine, Henry C. | 60,290 | Dec. 4, 1866 | D |
| Van Wyck, C. I. | 27,603 | Mar. 20, 1860 | W |
| Van Wyck, William. | 65,313 | May 28, 1867 | S |
| Vaughan, Aaron C. | 53,709 | Apr. 3, 1866 | G |
| Vaughan, John Ives. | 49,689 | Aug. 29, 1865 | F 1, 2, II |
| Von Boyen, Edgar. | 689,381 | Dec. 24, 1901 | C |
| Von Boyen, Edgar. | 690,693 | Jan. 7, 1902 | C |
| Vuilleumier, Rudolph. | 1,038,691 | Sept. 17, 1912 | K 1, B |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Von Groeling, A. F. G. P. J. | 1,295,088 | Feb. 18, 1919 | B |
| Waddell, Alexander. | 1,249,864 | Dec. 11, 1917 | K 1 |
| Waitz, J. W. | 1,105,727 | Aug. 4, 1914 | J, K 2 |
| Walker, Henry V. | 972,953 | Oct. 18, 1910 | D 1 |
| Walker, H. V. | 955,372 | Apr. 19, 1910 | V |
| Walker, W. E. | 1,307,280 | June 17, 1919 | L, K |
| Wallace, Geo. W. | 1,283,000 | Oct. 29, 1918 | W |
| Wallace, John Stewart. | 716,132 | Dec. 16, 1902 | D |
| Warden, Henry. | 266,929 | Oct. 31, 1882 | C |
| Warden, Wm. G. | 240,937 | May 3, 1881 | S |
| Warden, Wm. G. | 250,936 | May 3, 1881 | S, D |
| Warden, Wm. G. | 110,806 | Jan. 3, 1871 | F 1, II |
| Warden, Wm. G. | 112,751 | Mar. 14, 1871 | F 1 |
| Warfield, R. N. | 40,068 | Sept. 22, 1863 | V |
| Waring, Richard S. | 284,098 | Aug. 28, 1883 | T |
| Waring, Wilson. | 643,578 | Feb. 13, 1900 | I |
| Warren, Cyrus M. | 248,074 | Oct. 11, 1881 | T |
| Warren, Cyrus M. | 47,235 | Apr. 11, 1865 | U |
| Warren, John. | 97,998 | Dec. 14, 1869 | F |
| Warren, John. | 102,186 | Apr. 19, 1870 | S |
| Warren, John W. | 705,168 | July 22, 1902 | V |
| Warren, John W. | 666,446 | Jan. 22, 1901 | V |
| Warren, M. H. | 1,110,361 | Sept. 15, 1914 | B |
| Warth, C. H. | 1,131,880 | Mar. 16, 1915 | F 2, II, G |
| Washburn, C. H. | 1,138,266 | May 4, 1915 | B |
| Weisenberger, P. | 54,984 | May 22, 1866 | D 1 |
| Weiser, Josef. | 1,127,951 | Feb. 9, 1915 | S |
| Wellman, F. E. | 1,275,337 | Aug. 13, 1918 | B |
| Wells, A. A. | 1,232,454 | July 3, 1917 | B |
| Wells, A. A. | 1,187,874 | June 20, 1916 | B |
| Wells, A. A. | 1,248,225 | Nov. 27, 1917 | B, J |
| Wells, Willet C. & Wells, F. E. | 877,620 | Jan. 28, 1908 | F 1, 3, II |
| Wells, W. C. & F. E. | 1,296,244 | Mar. 4, 1919 | F |
| Welles, Wm. C. | 61,291 | Jan. 15, 1867 | S |
| Wellman, F. E. | 1,245,291 | Nov. 6, 1917 | B, S |
| Welsh, M. J. | 1,159,450 | Nov. 9, 1915 | C |
| Wemple, H. R. | 1,262,886 | Apr. 16, 1918 | K 1 |
| Wendtland, August. | 618,307 | Jan. 24, 1899 | C |
| Weston, Elijah. | 219,546 | Sept. 9, 1879 | S |
| Wetmore, I. W. | 39,978 | Sept. 15, 1863 | U |
| Wheeler, Norman W. | 52,477 | Feb. 6, 1866 | S |
| Whitall, Frank M. | 768,101 | Aug. 24, 1904 | T |
| Whitall, Samuel R. | 734,482 | July 21, 1903 | T |
| White, Carter. | 1,226,041 | May 15, 1917 | B |
| Whiting, Jas. R. | 622,936 | Apr. 11, 1890 | S |
| Whiting, J. R. & Lawrence, W. A. | 583,779 | June 1, 1897 | V |
| Whitmore, Samuel W. | 1,125,422 | Jan. 19, 1915 | F 1, II |
| Wiegand, S. Lloyd. | 39,607 | Aug. 18, 1863 | F 2 |
| Wiegand, S. Lloyd. | 62,583 | Mar. 5, 1867 | C |
| Wiggins, Isaac B. | 63,777 | Apr. 9, 1867 | M |
| Wilber, William. | 23,210 | Mar. 8, 1859 | M |
| Wilcox, L. N. | 49,020 | July 25, 1865 | F |
| Wilkinson, Asa W. | 145,707 | Dec. 19, 1873 | F 3 |
| Wilkinson, Walter S. | 512,348 | Jan. 9, 1894 | E 3 |
| Wilkinson, Walter S. | 597,892 | Jan. 25, 1898 | E 3 |
| Willard, Franklin W. | 26,739 | Jan. 3, 1880 | G, S |
| Willard, Franklin W. | 27,503 | Mar. 13, 1860 | F |
| Willard, Franklin W. | 27,327 | Feb. 28, 1860 | G, S |
| Williams, R. A. & Bragg, J. | 304,390 | Sept. 22, 1884 | S |
| Willis, Geo. M. | 918,628 | Apr. 20, 1909 | E 3 |
| Wilson, R. J. | 379,090 | Mar. 6, 1888 | F 4 |
| Wingett, John N. | 1,229,189 | June 5, 1917 | P |
| Wintz, Jas. P. | 807,983 | Dec. 19, 1905 | D |
| Wirkner, George von. | 783,916 | Feb. 28, 1905 | D 1 |
| Wolff, Albert. | 1,240,523 | Sept. 28, 1917 | D |
| Wolf, Hermann. | 604,280 | May 17, 1898 | D 1 |
| Wolf, Linus. | 1,265,573 | May 7, 1918 | K 1 |
| Wohle, Salo. | 1,081,801 | Dec. 16, 1913 | D 1 |
| Wynne, Edward W. | 901,411 | Oct. 20, 1908 | D |

## UNITED STATES PETROLEUM PATENTS—Con.

| Name | Number | Date | Class |
|---|---|---|---|
| Wallace, Geo. W. | 1,283,001 | Oct. 29, 1918 | F, W |
| Wells, Raymond. | 1,267,611 | May 28, 1918 | A |
| Wright, E. H. & Atwood, E. H. | 1,278,280 | Sept. 10, 1918 | F |
| Whitman, J. C. | 1,312,375 | Aug. 5, 1919 | O, S |
| Yaryan, Homer T. | 300,185 | June 10, 1884 | F 2, 5, II |
| Young, Jas. | 127,446 | June 4, 1872 | D 1 |
| Young, W. H. | 62,798 | Mar. 12, 1867 | O |
| Zerning, Hermann. | 1,183,266 | May 16, 1916 | J, K 2, B |
| Zimmerling, August F. | 313,795 | Mar. 10, 1885 | M |

## BOOKS ON PETROLEUM, ASPHALT AND NATURAL GAS

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|---|---|
| Abady—Gas Analyst's Manual | $ 6.50 |
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| Berlinerblau—Das Erdwachs, Ozokerit and Cerestin. 8vo. Brunswick, 1917. | |
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| Brannt—Petroleum: Its History, Origin, Occurrence, Production, Physical and Chemical Constitution, Technology, Examination and Uses. Philadelphia and London, 1895. | |
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| Clowes and Redwood—The Detenticn and Measurement of Inflammable Gas and Vapor in the Air. 8vo. London, 1916 | |
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| Dennis—Gas Analysis | 2.10 |
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    The Moloch of Paraffin. 8vo. London, 1886...........
    The Coming Deluge of Russia Petroleum, and its Bearings on British Trade. 1887.........................
    England as a Petroleum Power, or the Petroleum Fields of the British Empire. London, 1887..............
    Our Unappreciated Petroleum Empire. 8vo. London, 1889...........................................
    The Coming Oil Age: Petroleum—Past, Present, and Future. 8vo. London, 1889.......................
Mills—Destructive Distillation: a Manualette of the Paraffin, Coal-Tar, Rosin Oil, Petroleum, and kindred Industries. London, 1887...........................................
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London sliding scale for gas. 1909. (60th Congress, S. Doc. 696.) 5c.
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Supersedes 1st edition with title, "State and municipal regulations for gas," and 2d edition entitled, "Standard regulations for manufactured gas and gas service."

### U. S. GEOLOGIC SURVEY.

Annual Reports of Geological Survey. 22d. 1901. Part 1 Director's Report and paper on asphalt and bituminous rock deposits. 464 pages, illus., maps. $1.60.
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Asphalt and Bituminous rock deposits of United States. (In Geological Report 1901, pt. 1, pp. 209-452, 52 plates, illus. maps.) Cloth, $1.60.
Asphaltum deposits of California. (In Mineral Resources, 1883-4, pp. 938-948.) Cloth, 60c.
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| Gulf Coast Oil News | Houston, Texas |
| Journal du Petrole | Paris |
| Moniteur du Petrole Romain | Bucarest |
| Naphtha | Lemberg, Galicia |
| National Petroleum News | Cleveland, Ohio |
| Neftianoie Dielo | Baku |
| Oil City Derrick | Oil City, Pa. |
| Oil & Gas Journal (The Oil Investors' Journal) | Tulsa, Okla. |
| Oil and Gas News | Kansas City, Mo. |
| Oildom | New York City, N. Y. |
| Oil, Paint and Drug Reporter | New York City, N. Y. |
| The Oil Industry | Los Angeles, Calif. |
| Oil News | London, Chicago |
| Petroleum | Berlin |
| Petroleum | Chicago, Ill. |
| Petroleum Age | Chicago, Ill. |
| The Petroleum Gazette | Titusville, Pa. |
| The Petroleum Review | London |
| The Petroleum World | London |
| Revue du Petrole | Bucarest |
| Petroleum Review | |
| Petroleum Gazette | |
| Journal of Gas Lighting | Chicago, Ill. |
| Gas Record | Chicago, Ill. |
| Gas Engineering | New York City, N. Y. |

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(With articles on Petroleum, Asphalt and Natural Gas).

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| Chemical Abstracts of American Chemical Society | Easton, Pa. |
| Journal of Industrial and Engineering Chemistry | New York City, N. Y. |
| Journal of American Chemical Society | Easton, Pa. |
| Chemical and Metallurgical Engineering | New York City, N. Y. |
| Engineering and Mining Journal | New York City, N. Y. |
| Engineering News Record | New York City, N. Y. |
| Journal of the Society of Chemical Industry | London |
| American Society for Testing Materials | Philadelphia, Pa. |
| International Society for Testing Materials | |
| Journal of the Franklin Institute | Philadelphia, Pa. |
| Institute of Mining Engineers | New York City, N. Y. |

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## ALABAMA.

Circular No. 3. Concerning oil and gas in Alabama, by E. A. Smith.
Bulletin No. 10. The Fayette Gas Field.
Bulletins Nos. 20, 22, 23, 28, 31, 33, 35.

## KANSAS.

Vol. IX. Oil and Gas.
Bulletin No. 3. Oil and Gas Resources of Kansas.

## KENTUCKY.

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